INVESTIGATING SCIENCE WITH CHILDREN / VOLUME 1

LIVING THINGS

National Science Teachers Association

88/28

INVESTIGATING SCIENCE WITH CHILDREN

STATE INSTITUTE OF EDUCATION
Govt. of West Bengal

VOLUME 1

LIVING THINGS

JAMES R. WAILES, Professor of Education
University of Colorado, Boulder, Colorado

Produced as a Joint Project of
National Science Teachers Association and
National Aeronautics and Space Administration

S.C.E.R.T. Library
[illegible]
Calcutta
25/3, B. C. Road

Published by
TEACHERS PUBLISHING CORPORATION
Darien, Connecticut

INVESTIGATING SCIENCE WITH CHILDREN SERIES

Volume 1 LIVING THINGS
Volume 2 THE EARTH
Volume 3 ATOMS AND MOLECULES
Volume 4 MOTION
Volume 5 ENERGY IN WAVES
Volume 6 SPACE

S.C.E.R.T., W B LIBRARY
Date 9.8.05
Accn. No. 11771

© National Science Teachers Association 1964

All rights reserved—no part of this book may be reproduced in any form without permission in writing from the publisher, except by a reviewer who wishes to quote brief passages in connection with a review written for inclusion in magazine or newspaper.

The National Science Teachers Association is a department of the National Education Association (NEA) and an affiliate of the American Association for the Advancement of Science (AAAS).

About the cover: A young girl and a dandelion, whose seeds are being blown from the stalk to be borne by the wind to a site where they can take root and grow, are symbolic of the plant and animal life that inhabits the Earth.

Printed in the United States of America
Library of Congress Catalog Card No. 64-22841

CONTENTS

PAGE

1 INTRODUCTION 5

Characteristics of Living Things
Plants and Animals — Their Similarities and Differences

2 INVESTIGATING THE CHARACTERISTICS AND NEEDS OF PLANTS 7

What Are the Characteristics and Needs of Green Plants?
What Are the Characteristics and Needs of Nongreen Plants?

3 INVESTIGATING THE CHARACTERISTICS AND NEEDS OF ANIMALS 28

4 INVESTIGATING ADAPTATIONS OF LIVING THINGS 45

How Do Animals Respond to Their Environment?
How Do Plants Respond to Their Environment?
How Is the Interdependence of Plants and Animals Important In Space Travel?

5 INVESTIGATING LIVING THINGS THROUGH FIELD TRIPS 74

Visiting a Biome
Visiting a Field
Visiting a Pond
Visiting Other Biomes
Visiting the Zoo
Visiting a Botanical Garden
Visiting an Aquarium

About the INVESTIGATING SCIENCE WITH CHILDREN Series

These six handbooks for the teaching of science in the elementary school have the distinguished sponsorship of two leading groups concerned with the improvement of science teaching: NSTA (The National Science Teachers Association) and NASA (The National Aeronautics and Space Administration). Initiated by NSTA, the series received technical and financial assistance from NASA. The six authors were carefully chosen by NSTA and NASA from among leading science educators in the United States and Canada. The series has been carefully planned, developed, and edited over a period of two years. It updates and replaces the widely successful SCIENCE TEACHING TODAY series by Dr. Guy Bruce, published bv NSTA in 1950.

General approach and philosophy. As they planned this series of books, members of the writing team were concerned with the following questions: What are some things we can or should do to help teachers as they investigate the world of science with children? In what direction should we move? How can we incorporate into our writings the processes and content of science, the fostering of creativity in children, provisions for children's varying abilities?

The age and culture in which we live demand that children in the elementary schools have a variety of real science experiences that lead them to an understanding of the world about them. Through a variety of science experiences, each individual will come to understand and to use scientific processes and skills, as well as to acquire the specific science learnings that will help him live intelligently.

Since each book in the series is concerned with one area of science and moves from simple concepts to more complex ones within each chapter, *each* teacher, at any grade level, will find that *all* the books have materials that she can use in her teaching.

Question–discovery approach used. Throughout each book, questions are used in several different ways. At the beginning of each chapter is a list of questions that children of different ages might ask. Answers to these questions and others are found when the children become involved in doing the Activities of the specific chapter. Other questions, with answers containing the science information given in parentheses for the teacher, are included within each Activity to help teachers as they guide the children's learning. More questions are listed later, as open-end Activities to be used with those children who may wish to make further investigations.

Organization keyed to varying abilities. To provide for varying abilities of the children in a group and at different grade levels, as well as to make possible a developmental approach to concept formation, the Activities and learnings are purposely not "graded," but are designated by the following symbols: x for those Activities involving beginning learnings; y for those Activities requiring more skill and involving several learnings; and z for those Activities of considerable difficulty and involving more complex thought patterns. An introduction is included with each Activity, which is merely suggestive and which may give the teacher ideas helpful in challenging children's thinking.

Illustrations and format. All six of the volumes are filled with helpful illustrations that will help the teacher as she directs the children's participation in the Activities. A two-column format allows for easy reading and clear organization, for in-class presentation.

Summaries and references. Each chapter concludes with a summary of the main ideas developed by the author. Throughout each book, cross references are made to Activities and science content found in the other books of the series. At the end of each book there is a list of bibliographical references that contain additional science information.

Scientific accuracy assured. One of the concerns of the writing team was the scientific accuracy of the information appearing in each book. To insure such accuracy, leading scientists who are specialists in their respective fields were asked to read and review the content during the preparation of the manuscripts. Their names appear at the end of this section.

It is hoped that this series of books, INVESTIGATING SCIENCE WITH CHILDREN, will be helpful in providing opportunities for children to use many processes of inquiry —investigating, observing, problem-solving, hypothesizing, experimenting, thinking, checking, analyzing—as they try to find the *what, how,* and *why* of the world around them. There are no final answers in these books. Let the series be thought of as a challenge to teachers to further learning.

Acknowledgments. Many people have made this series possible. The authors and series editor wish to express their appreciation to Robert Carleton, Executive Secretary of the National Science Teachers Association, for his confidence in the project and for his many words of encouragement; to Frank Salamon, Specialist in Elementary Science, National Science Teachers Association, for his guidance through various stages of the project; to Everett Collin, Mattison L. Story, and George Gardner, Education Specialists, National Aeronautics and Space Administration Education Program, for their interest in the project and for their reading of the manuscripts; and to Lila J. Phillips, Editor for this series, Teachers Publishing Corporation, for her aid in the preparation of the final manuscripts.

To the following scientists, who read the manuscripts in their preliminary form for scientific accuracy, the authors and series editor are deeply indebted for their many helpful comments and reactions: Dr. M. G. Seeley, University of Arizona, Tucson, Arizona; Dr. Alexander Calandra, Washington University, St. Louis, Missouri; Dr. Albert R. Hibbs, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California; Dr. William Mathews III, Lamar State College of Technology, Lamar, Texas; and Dr. Barbara Collins, Geologist, Northridge, California.

RUTH L. ROCHE, Series Editor
ARTHUR COSTA
LOUIS T. COX, JR.
LOIS E. DUNN
LAWRENCE HUBBELL
SEYMOUR TRIEGER
JAMES R. WAILES

1

INTRODUCTION

"What will my children bring in today?" is a common question asked by elementary teachers as the school day begins. The teacher will not be disappointed. The following list of things brought in by children was compiled by a primary teacher the first three days of school: a snake, a toad, butterflies, a wide variety of leaves, various insects, pine cones, seeds, a dog, two cats, a turtle, and caterpillars and several cocoons.

An upper-grade teacher reported the following comment: "Here is a spider, Mrs. Berrong. I *knew* you would want it."

Living things play an important role in the lives of children, as noted in the two paragraphs above. Questions are constantly forthcoming from the pupils, and numerous activities can be employed to answer some of these inquiries. Children's questions know no bounds. Many of the questions they ask are similar to those that scientists are trying to answer. Below are some typical questions asked by children concerning the general area of the various conditions necessary for life:

"Are you sure it is a plant? It isn't green!"

"Where do caterpillars come from and what do they eat?"

"Could we do an experiment to see why it grows that way?"

"Where does that fuzzy stuff on bread come from?"

"How can an astronaut live in space for long periods of time?"

"How can you tell a butterfly from a moth?"

"Can we hatch a butterfly in our room from a caterpillar?"

These are but a few of the numerous questions that teachers have had to face in the past and will undoubtedly face in the future. The Activities in this book present ideas that the teacher can use to help the children find answers to a few of their questions. Some background information for the teacher is presented in this chapter and in parentheses throughout the text.

CHARACTERISTICS OF LIVING THINGS

The known living things include all plants and animals, including man. All living things are called organisms. Organisms that are too small to be seen with the naked eye are called microorganisms, *micro* meaning small.

All living things have certain characteristics and perform particular activities that nonliving things do not. For example, all living things need food, grow to a particular size, live a certain amount of time, reproduce, and respond to changes in their environment.

These characteristics and activities help scientists determine what life is. However, sometimes it is difficult to distinguish a living thing from one that is not living. For example, scientists still do not know if the microorganisms known as viruses (some of which cause diseases) are living or nonliving. Viruses act like living things in that they grow and reproduce; but they also act like some chemicals, which are *not* living, in that they form crystals.

The Basis of Life. All living things consist of a complex substance called protoplasm. Living protoplasm is constantly active, and its activities enable life to continue. Protoplasm does not just fill up an organism; it is organized into small units called cells. Cells are the building blocks of life. They make up all living things. Some organisms, such as the amoeba, a tiny aquatic animal, consist of only one cell. Other organisms, such as man, consist of billions of cells.

The Requirements of Living Things. All plants and animals take in materials from their surroundings and use these materials to keep themselves alive. Different materials are required by plants and by animals. For example, plants need light, air, and water in order to live. They use these materials to make food. Like plants, animals need light, air, and water, but they also need food. Unlike plants, however, animals cannot make their own food. Instead, animals get their food either by eating plants or by eating other animals that have fed on plants.

Growth. The materials that organisms take in are also used to make new protoplasm. New protoplasm is contantly being formed. During some stages in an organism's lifetime *extra* protoplasm is manufactured. This protoplasm enables an organism to grow, or increase in size.

All living things eventually stop growing. When an organism reaches a particular size, growth ceases. This is why, for example, a boy does not grow to be the size of an elephant. Each living thing grows to a size characteristic for that organism.

Life-span. Living things do not live forever. Like growth, an organism's life-span is characteristic for that kind of living thing. For example, adult mayflies, a certain kind of insect, live for only one day. On the other hand, sequoia trees, giant trees that grow in California, may live for thousands of years.

Reproduction. Living things reproduce, that is, they produce new living things like themselves. Nonliving things cannot reproduce.

The method by which organisms reproduce varies, depending on the particular animal or plant. Chickens and other birds reproduce by eggs. In many animals, such as cats and dogs, the young develop from eggs inside the mother's body and are born live. Flowering plants reproduce by seeds. Other plants, such as mushrooms, reproduce by means of spores. Because all living things die, reproduction is necessary for life to continue. If a particular species, or kind of organism, stops reproducing, it ceases to exist. When this happens, that organism is said to be extinct. An example of such an extinct organism is the dodo, a bird similar to the pigeon but about the size of a turkey. Dodo birds once lived in great numbers on islands in the Indian Ocean, but many were killed by people who settled on the islands. Eventually all the dodo birds were killed, leaving none to reproduce. Therefore the dodo bird no longer exists; it is extinct.

Responses to Changes in the Environment. Living things respond to stimuli, or changes, in their environment. Light, heat, cold, sound, and pressure are among the many stimuli to which organisms respond. The response of organisms to stimuli is called *irritability*.

Different organisms respond differently to the same stimulus. For example, some animals, such as moths and mosquitoes, are attracted by, and fly toward, light. On the other hand, animals such as the earthworm and the mole avoid light and move away from it.

PLANTS AND ANIMALS—THEIR SIMILARITIES AND DIFFERENCES

Plants and animals are alike in that they are both living things. As living things, both plants and animals respond to their surroundings, they grow and develop, and they produce offspring like themselves. Plants and animals are also similar in that they both consist of a complex substance called protoplasm, which is organized into microscopic units called cells.

Although all cells are basically alike, plant cells differ from animal cells. For example, a plant cell is usually enclosed by a nonliving cell wall. The cell wall consists of cellulose, a tough substance that makes a plant rigid and stiff. An animal cell is not surrounded by a cell wall.

Plants and animals also differ in the manner in which they obtain their food. Most plants make their own food by a process called *photosynthesis*. In this process, plants use the green pigment *chlorophyll*, in the presence of light, to convert carbon dioxide and water into food. Unlike plants, animals cannot make their own food. As a result, they must obtain all their food either by eating plants or by eating other animals that have fed on plants.

Another difference between plants and animals is that most animals are able to move about in their environment, while most plants cannot. However, a few plants, such as the Venus's-flytrap, have special structures that do move.

2

INVESTIGATING THE CHARACTERISTICS AND NEEDS OF PLANTS

All plants are generally divided into two large groups: green plants and nongreen plants. This division is based on the method by which plants obtain their food. Most green plants make their own food and most nongreen plants do not. There are, however, many exceptions to this classification.

Green plants generally include algae, liverworts, mosses, ferns, conifers, and flowering plants. Green plants are able to manufacture their own food because they contain chlorophyll, the green pigment that gives them their characteristic green color. Using chlorophyll, green plants make food from the water and carbon dioxide in their surroundings. This food-making process is called photosynthesis. Some nongreen plants, such as certain kinds of bacteria, are also able to manufacture their own food, but they do it by a process other than photosynthesis.

Nongreen plants include most bacteria and fungi, such as mushrooms. Unlike green plants, nongreen plants lack chlorophyll and therefore cannot carry out photosynthesis. As a result, they must obtain all or part of their food from sources other than themselves. The food sources for the nongreen plants are other organisms, which may be living or dead plants or animals. The plant or animal being used as a source of food is called the host.

Generally, nongreen plants are subdivided into two groups, depending on whether the host is living or dead. Plants that obtain their food from living organisms are called parasites. Plants that obtain their food from nonliving organisms are called saprophytes. Included in the parasites are many microorganisms, such as fungi that cause various plant and animal diseases. A common example of saprophytes are mushrooms.

Although green plants usually can make their own food and nongreen plants cannot, some plants do not act in the manner characteristic of their group. For example, some nongreen plants, such as certain kinds of bacteria, are able to manufacture their own food, but they do not do it by photosynthesis. On the other hand, some green flowering plants, such as certain kinds of mistletoe, act like nongreen plants and obtain some of their food from other plants.

WHAT ARE THE CHARACTERISTICS OF GREEN PLANTS?

Most green plants have roots, stems, leaves, and flowers. These structures perform functions that enable the plants to live and reproduce. The flowers are structures for reproduction, and they produce the seeds that give rise to new plants. The roots anchor the plant in the soil and also absorb water and dissolved minerals from the soil. The stem carries the water and minerals from the roots to the leaves. In the leaves the water is used to make food by the process called *photosynthesis.* The stem also carries the food to other parts of the plant where it is either stored or used.

Photosynthesis is a food manufacturing process. It occurs only in the leaves of green plants and in the presence of light. Besides providing nourishment for plants, photosynthesis also provides food for the animals that eat plants. Animals are not able to make their own food, and therefore must rely on plants for it. Animals could not live without green, leaf-bearing, food-manufacturing plants. These plants are the only living things that are able to use the energy of sunlight to make substances useful to both plants and animals.

Plants need four things in order to make food. These are (1) water, (2) carbon dioxide, (3) chlorophyll, and (4) light. If any one of these things is missing—for example, at night when there is no light—photosynthesis does not occur. In addition, all four things must be *in* the leaf. Chlorophyll, the green chemical that gives plants their green color, is already in the leaf. Water, carbon dioxide, and light are provided by the environment around the plant. Water is absorbed from the ground by the roots of the plant and is sent to the leaf by way of special ducts in the plant stem. Carbon dioxide, present in the air, enters the leaf through tiny holes on the underside of the leaf's surface. Light may come from sunlight or from artificial sources, such as fluorescent lamps. It provides the energy for the photosynthetic process and is absorbed by the chlorophyll in the leaf.

Water and the carbon dioxide may be considered the actual ingredients of photosynthesis, with light and chlorophyll the things that start the process and keep it going. The end product of photosynthesis is food—in the form of energy-rich sugars. The energy the sugars contain comes from the energy of light.

The waste product of photosynthesis is oxygen. Oxygen is released to the environment through the same tiny holes in the leaf's surface that admit carbon dioxide. The oxygen replaces that used up by the respiration of plants and animals. At night, when no light is available, plants do not carry on photosynthesis. They then take in oxygen and give off carbon dioxide in order to continue respiration and produce the energy needed for their life processes.

A plant may use the food it manufactures in a number of ways. It may break down the sugars into simpler substances and use them as a source of energy. It may also convert, or change, the sugars into starch, which is stored in the plant as a future source of energy. The sugars may also be converted into substances, such as cellulose, that the plant uses to build new tissue for growth.

ACTIVITY 1 (x)

DISCOVERING THE NATURE OF SEEDS

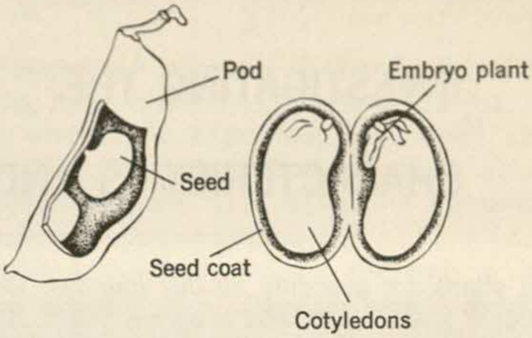
Purpose: To discover the structure of seeds

Concept to be developed: A seed consists of an embryo plant and stored food enclosed in a seed coat.

Materials needed:

Lima bean seeds (packaged garden seed, not cooking beans)
Paring knives

THE LIMA BEAN SEED



The night before you plan to use this Activity, soak half of the lima bean seeds in water so that the seed covering will be soft. Distribute several of the dried lima bean seeds to the children and ask them to describe the seeds. They should notice that the seeds are smooth, hard, and dry, and they should be able to find the place where each seed was attached to the plant. Then distribute the seeds that have been soaked overnight and ask the children to break the coatings of the seeds and open them. Ask the children to describe the parts of a seed. Have the children describe the coat of the seed and suggest its function. *(The seed coat protects the content of the seed.)* Ask the children to describe the contents of the seed and to suggest the function of the parts. They should notice that there is a tiny plant between two cotyledons. The tiny plant develops into the adult plant, and the cotyledons contain stored food.

As preparation for the next Activity, ask the children to suggest what conditions are necessary to cause the seed to grow into a plant.

Extending Ideas: Suggest to the children that they make lists of seeds that we eat as food. Help them develop the idea that we eat the food produced by the plant for the development of the plant embryo. Have the children make a collection of the many different kinds of seeds that we use as food.

Learning: (x) A seed consists of a protective coat, an embryo plant, and one or more cotyledons that contain food for the growth of the embryo plant.

ACTIVITY 2 (x)

INVESTIGATING SEED GERMINATION

Purpose: To demonstrate that both water and air are needed for germination

Concept to be developed: Seeds need both water and air for germination.

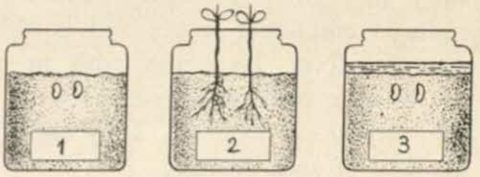
Materials needed:

Lima bean seeds (packaged garden seed, not cooking beans)
Potting soil
3 glass jars

INTRODUCTION: Ask the children to suggest ideas as to how the lima bean seed could be made to develop into plants. You may wish to tell the class that the process by which a seed becomes a plant is called germination.

The children will probably suggest soil, water, and air. Suggest that they plant beans under three different conditions. The following Activity will enable them to observe the germination of seeds under varying conditions.

Suggest that the children divide the bean seeds into three groups. Fill each of the glass jars about ¾ full with potting soil. Have the children poke several bean seeds between the inside of the jar and the potting soil so that the seeds are about ½ inch from the surface of the soil. Ask the children to label each glass jar with a number. Explain to them that labels are necessary to keep accurate records. Have the children place all three jars in a warm location. The seeds in Jar 1 will receive no water at all. The seeds in Jar 2 will be watered just enough to keep the soil moist. The seeds in Jar 3 should be watered until water appears above the surface of the soil.



No water
Soil dry

Some water
Soil moist

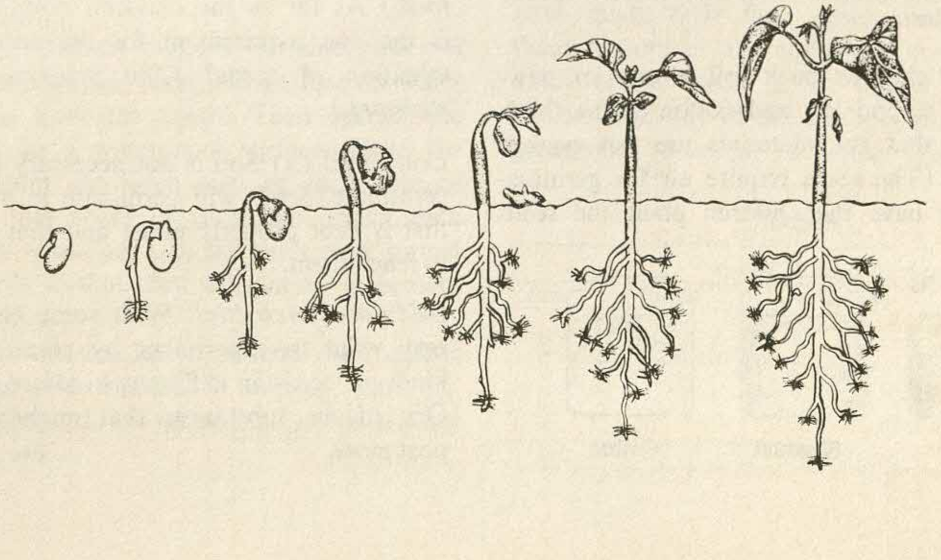
Excess water
Soil flooded

Jars 2 and 3 should be watered to maintain the conditions described. Have the children observe the jars each day and keep records of the seeds' growth. They might prepare a chart as shown in the illustration.

After a week, discuss the results the children recorded in the chart. The seeds in Jar 1 should not have sprouted at all. Why? *(The seeds in Jar 1 received air but did not receive moisture. Both air and moisture are required for germination.)* The seeds in Jar 2 should have sprouted. Why? *(The seeds were provided with air and moisture.)* The seeds in Jar 3 should not have sprouted and may even have begun to rot. Why? *(Seeds require both air and moisture, but moisture without air is not sufficient for the germination. The seeds in Jar 3 were always completely covered with water and, therefore, received no air.)*

Extending Ideas: In the germination of seeds, the embryo plant uses both air and water to grow. The children may wish to continue to record the development of the plant. They should notice that as each plant grows, the cotyledons

GERMINATION OF A BEAN SEED



become smaller as the stored food is used up. Eventually, they drop off entirely when a plant has produced additional leaves and is able to make its own food. They may wish to make drawings of their plant beginning with the seed until the cotyledons drop off. They should record the date of each drawing.

Learnings: (x) Seeds require the proper amount of both water and air in order to germinate. During the germination period, seeds use food stored in the cotyledons.

ACTIVITY 3 (x)

GERMINATING SEEDS IN DIFFERENT SUBSTANCES

Purpose: To find out that soil is not necessary for the germination of seeds

Concept to be developed: Seeds will germinate in any substance that is kept properly moist.

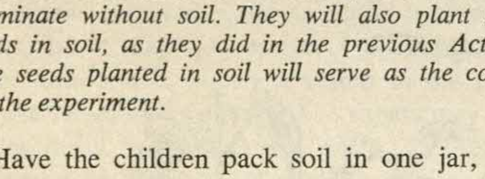
Materials needed:

- Lima bean seeds (packaged garden seed)
- Potting soil
- Sawdust
- Cotton
- Glass jars
- Water
- Rulers

INTRODUCTION: Review the germination of seeds with the children. Remind them that in Activities 1 and 2 they learned that seeds need a proper amount of moisture and air to germinate successfully. Do they think that seeds need soil in order to germinate? Would seeds planted in moist sawdust germinate? Would seeds germinate in moist cotton?

After the children have given their answers, suggest to the class that in this Activity they will plant seeds in these materials to see if the seeds will germinate without soil. They will also plant some seeds in soil, as they did in the previous Activity. The seeds planted in soil will serve as the control for the experiment.

Have the children pack soil in one jar, sawdust in the second jar, and cotton in the third. Make sure that the materials are not packed too tightly. (The seeds require air for germination.) Next have the children plant the seeds about ½ inch beneath the surface of the material in each jar. The seeds should be placed near the outside of the glass where the children can watch them to see if they germinate. After the seeds are planted, each jar should be watered, making sure that just enough water is added to moisten the material in which the seeds are planted. The jars should be placed in a warm part of the room. Each day the children should check them for moisture, adding water as necessary to keep the material moist. For ten days the children should watch the seeds for evidence of germination. In a chart like the following, they should record their observations of how soon the seeds germinate, how high the young seedlings are, what structures appear, etc.



COTTON

Time	Time of Germination	Height of Seedling	Other
1 day			
2 days			
3 days			
4 days			

After the children have made their final observations, encourage them to answer the following questions. Did the seeds that were planted in sawdust germinate? *(Yes.)* Did the seeds that were planted in cotton germinate? *(Yes.)* Did the seeds planted in soil germinate? *(Yes.)* Was there any noticeable difference in the ability of the seeds to germinate successfully? Or will seeds germinate in any moist material? *(As the children learned in Activity 1, seeds contain their own food supply. This makes it possible for them to germinate in any moist material because they do not need additional food.)* As far as the children now know, what is the one requirement for the successful germination of seeds? *(The proper amount of moisture.)*

Learnings: (x) Soil is not necessary for seeds to germinate. Seeds will germinate in any material that is kept properly moist and that permits air to reach them.

Additional Activities: With some children, you may want to experiment by planting different kinds of seeds in different kinds of substances. One of the substances that might be used is peat moss.

ACTIVITY 4 (x)

OBSERVING TEMPERATURE AND SEED GERMINATION

Purpose: To find out the effect of temperature on the germination of seeds

Concepts to be developed: One of the conditions affecting seed germination is temperature. The temperature needed for germination varies, depending on the kind of seed.

Materials needed:

Radish seeds (packaged garden kind)
Sunflower seeds (packaged garden kind)
Wheat seeds (packaged kind)
9 pieces of clean cotton cloth cut into 12 x 12 inch squares (Terry cloth toweling works very well.)
Water
Rubber bands
Freezer
Refrigerator
3 thermometers

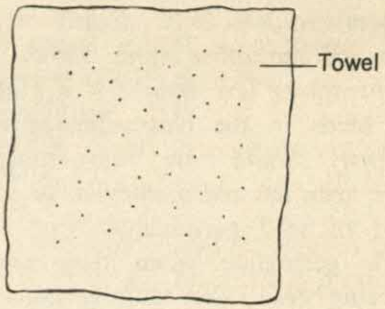
INTRODUCTION: Ask the children if they have ever seen seeds planted. At what time of year was the planting done? (Seeds are often planted at different times of the year, depending on the kind of seed.)

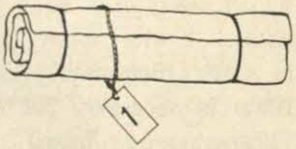
Ask the class what seeds must do before they can grow into new plants. Review with the children what they learned about germination in Activity 2. Do the children think that seeds planted in the winter would germinate? Elicit their theories. Explain that, in addition to the right amount of water, seeds require a suitably warm temperature to germinate, and the temperature varies for different seeds. This is one reason why seeds are planted at different times of year. The children can find this out by trying the following Activity.

Explain to the children that in this Activity they will try germinating seeds at three different temperatures. Suggest that they can also find out if different seeds germinate at different times by using three kinds of seeds: radish, wheat, and sunflower.

Have the children moisten the nine pieces of cloth and then wring them out so that no water is dripping from the cloth. Then spread the cloths out on a waterproof surface. Have the children count out three piles of each kind of seed with fifty seeds in each pile. Place each pile of fifty seeds on a moist cloth, and spread out the seeds so that they will not be in contact with each other.

Roll the cloth and fasten the ends with rubber bands. The rolls should be labeled with different numbers: 1 for radish, 2 for wheat, and 3 for sunflower.





Have the children place one roll of each kind of seed in the freezer in the school kitchen. If there is no thermometer in the freezer, have them place a thermometer in the freezer. (If no freezer is available in the school, one of the children might take the roll home and place it in the home freezer.) Next, have the children place one roll of each kind of seed and a thermometer in the refrigerator. One roll of each kind of seed should be kept in the classroom at room temperature. The rolls in the refrigerator and in the classroom should be kept moist during the experiment.

For ten days, at intervals of two days, have the children unroll the cloths and count the number of seeds that have germinated in each set. They should also make a record of the temperature in each of the places where the rolls are kept. Their observations can be recorded in a table such as the one illustrated. After the children have made their final observation, encourage them to answer the following questions. How many of the seeds in the freezer germinated? *(None.)* Did any of the seeds in the refrigerator germinate? *(Some of the wheat seeds may have*

RADISH

	Number of Seeds Germinating		
Days	Freezer	Refrigerator	Classroom
	Temp.	Temp.	Temp.
2			
4			
6			
8			
10			

germinated. Wheat seeds may start germinating at temperatures only slightly above freezing. None of the other seeds should germinate at temperatures less than 68° F.) How many of the seeds in the classroom germinated? *(The majority should have; those that did not may have been too old, damaged, or inactive.)* What kind of seed germinated first? *(Radish.)* Can seeds germinate when they are kept below freezing? *(No.)* Can seeds germinate in the cold? *(Some seeds can germinate in fairly cold conditions. The wheat seeds may have germinated in the refrigerator.)* Under what conditions did most of the seeds germinate? *(At room temperature.)* What is necessary for most seeds to germinate? *(Warm surroundings.)*

Learnings: (x) Temperature has an effect on germination. (x) Most seeds germinate best at warm temperatures. (x) Seeds will not germinate at temperatures below freezing. (x,y) Some seeds, such as wheat, can germinate at relatively cold temperatures. (x,y) Some seeds require a longer time to germinate than others.

Additional Activities: The children can vary this experiment by using other kinds of seeds and by varying the temperature in other ways. Have the children consider the possibility of plant life on other planets. They will have to find out about air, temperature, and moisture conditions on the various planets.*

ACTIVITY 5 (x)

PLANTING SEEDS AT DIFFERENT DEPTHS

Purpose: To find out what effect the depth of planting has on seed germination and growth into new plants

Concept to be developed: Seeds can germinate at any depth of planting but only seedlings planted at shallow depths will reach the surface and develop into new plants.

Materials needed:

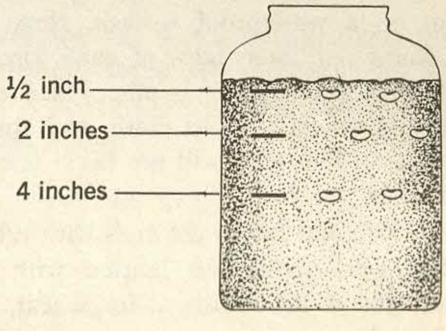
- Several kinds of seeds, such as bean, corn, cucumber, radish, and pea seeds (packaged garden kind)
- Several large glass jars, such as 1-gallon pickle jars (one for each kind of seed) or a glass-sided root box
- Potting soil
- Rulers
- Grease pencils or crayons
- Water

INTRODUCTION: Review germination of seeds with the children. Help them to recall the factors that are necessary for successful germination—the proper amount of moisture, suitable temperature, and air. Remind them that the seeds that have germinated in previous Activities were placed only ½ inch deep in the soil. Tell them that seeds are always planted at shallow depths. Some small seeds, such as radish seeds, are planted scarcely below the surface of the soil.

Now pass around the packages of seeds to the children and have them read the planting instructions. The package will state at what depth each kind of seed should be planted. Ask the class what they think would happen if the directions were not followed and the seeds were planted at depths greater than those specified. (They probably will guess that the seedlings will not come up.) *Will the seeds germinate even if no plants appear?* (Yes, but the class probably will not know this.) *Ask the class if they would like to perform an experiment to find out what happens to seeds that are planted at various depths.*

Divide the children into groups. Give each group one kind of seed and one jar, which they should prepare as follows. Using a grease pencil or crayon, make a line near the top of the jar (this will be the level of the soil when the experiment is completely set up). Then measure down from this and make three more marks, one ½ inch from the top line, one 2 inches from the top line, and one 4 inches from the top line. (These marks will indicate the various depths at which the seeds will be planted.)

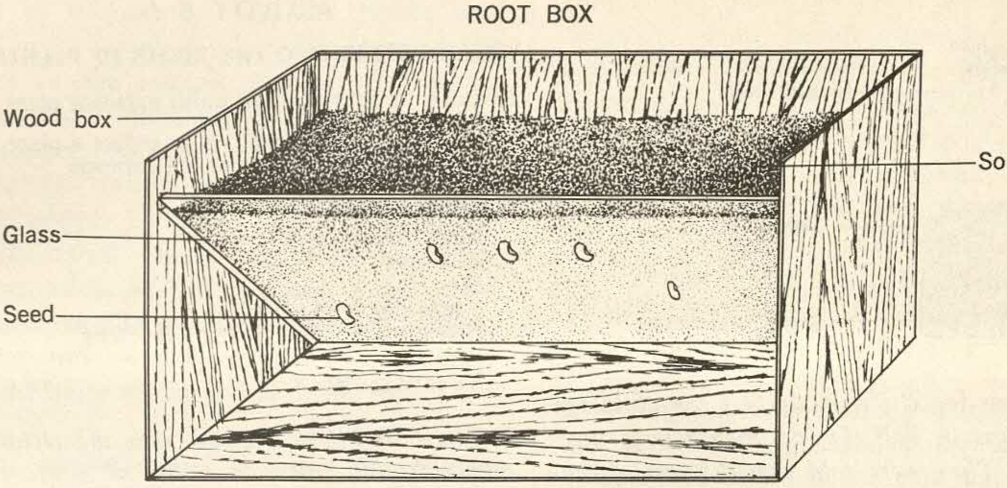
Now have the children put soil into the container until it reaches the 4-inch line they have marked off. The soil should be loosely packed, as they have learned to do in previous Activities. They should then place several seeds on the soil next to the glass (so that they can watch them for evidence of germination). Next



---

* For a more complete discussion of this, see *Space,* by Arthur Costa (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

ROOT BOX



they should add more soil, packing it loosely, until it reaches the 2-inch mark. Again, they should place several seeds next to the glass. (If a jar, rather than a root box, is used, make sure that the seeds are not directly above the seeds on the 4-inch level.) Now the children should add more soil, bringing the level up to the ½-inch line, and again place several seeds on the soil, taking care of the lower levels. They should then add more soil to cover these seeds and to bring the soil up to the line they have marked for the top level. When this is completed, each group will have a jar in which seeds are buried in ½ inch of soil, 2 inches of soil, and 4 inches of soil. The soil should be moistened carefully, making sure that there is not too much water for germination (the children learned how to do this correctly in Activity 2). For the rest of the experiment, water should be added as necessary to keep the soil properly moist. The jar should be kept in a warm dark place in the classroom—in a closet, for example.

INSTITUTE OF ... West Bengal

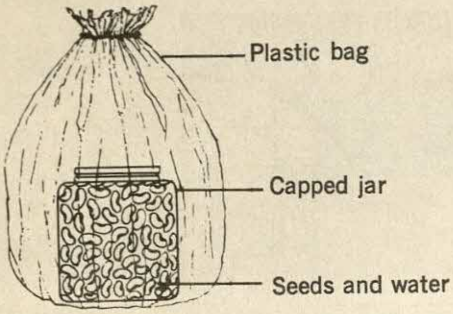
The children should watch the seeds for four days. Each day they should record how many seeds have germinated in each jar. They could keep their record in the form of a chart. At the end of the four days discuss the results with the children. How many of the seeds germinated at the ½-inch level? At the 2-inch level? At the 4-inch level? *(Most of the seeds at each level should germinate.)* Does the depth of planting have an effect on the germinating ability of seeds? *(No.)* Encourage the children to give their ideas about why seeds are planted at shallow depths. (They probably will not know the answer.)

Suggest to the children that if they keep the jars they may be able to find out why seeds are planted at shallow depths. Keep the jars in the dark and water them often enough so that the soil will be kept moist. After a week's time the children should record how many seedlings in each jar have appeared above the surface. They should also note from what level the seedlings came up. They may then watch the seeds for another week or two to see if any more seedlings come up. Their observations can be recorded on a chart such as the following:

JAR 2 — CORN

Level At Which Seeds Were Planted	Number Of Seeds That Germinated	Number Of Seedlings That Came Up
½ inch		
2 inches		
4 inches		

When the experiment is completed, ask the children the following questions. How many seedlings came up? Did any of the seeds planted at the 4-inch level come up? *(No.)* Did any plants from seeds planted at the 2-inch level come up? If so, what kind? *(The plants from large seeds, such as corn, probably did. Plants from small seeds, such as radish, probably did not.)* Did any of the seeds that were planted at the ½-inch level come up? *(Probably all the plants from seeds that germinated came up.)* Can the children explain why the seeds planted 4 inches deep did not come up? They may not be able to do this. The following questions may help to elicit the answer. Where do germinating



plants get their food? *(In Activity 1 the children cut lima beans in half. Inside they saw a tiny young plant. They were told that the rest of the bean was stored food material for the tiny plant.)* Now ask them where mature plants get their food. *(They have been told that plants manufacture their own food and that they can do this only in the sunshine.)* What would happen to a seed if it ran out of stored food before it got to the surface and could make its own food? *(The seedling would die.)* Why did some seeds that were planted 2 inches deep come up and others did not? *(Larger seeds have more stored food than tiny seeds. Tiny seeds must be planted very close to the surface so that they will not run out of food before they get into the light where they can make their own food.)*

Learnings: (x) The depth at which seeds are planted has no effect on their ability to germinate. They will germinate at any depth as long as they have the proper amount of air and moisture and are kept at a suitable temperature. (y,z) If seeds are planted too deep, however, the seedlings that develop will die before they reach the surface. This occurs because the seedling runs out of stored food before it gets into sunlight and can make its own food. (x) Seeds should be planted at shallow depths.

Additional Activity: Children will be fascinated by the following activity, which demonstrates the force produced as the seeds absorb water and swell. This process is called imbibition. Fill a small glass jar with bean seeds, and then fill it to the brim with water. Tightly screw the lid on the jar. Place the jar in a plastic bag sealed with a rubber band, and leave it overnight in a wooden or cardboard box. Check the jar the next morning. *(The jar should be broken.)*

ACTIVITY 6 (x,y)

WATER PASSES INTO THE ROOTS OF PLANTS

Purpose: To find out how water enters a plant

Concept to be developed: Water enters a plant through the roots by the process called osmosis.

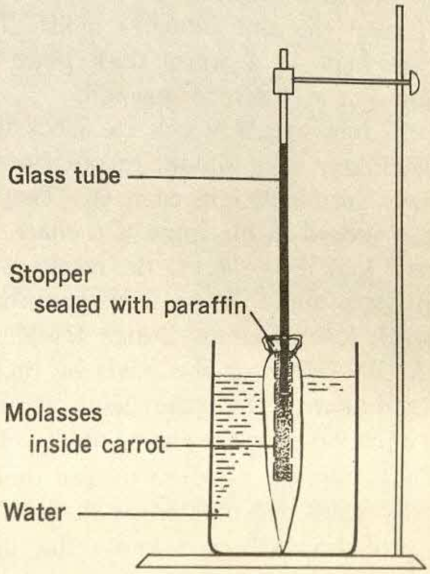
Materials needed:

Large carrot
Molasses
Jar
1-hole rubber stopper
Hollow glass tubing, about 2 feet long
Paraffin
Ruler or yardstick

INTRODUCTION: Review with the children that plants require water in order to grow. Ask the children how the water gets into the plant. They will probably suggest that it enters through the roots. This Activity will enable them to find out how water enters the plant and passes through the roots.

Water enters the root and passes from one cell to the next by a process called osmosis. In this process, water molecules pass through the membrane surrounding the plant cell from an area where there is a higher concentration of water to an area where there is a lower concentration of water. The membrane surrounding the cell is semipermeable. It will permit some substances such as water to pass through it but will not permit others to pass through.

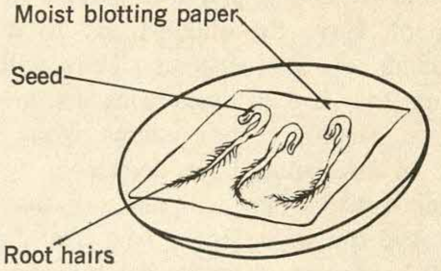
Suggest to the children that a carrot can be used as a root to observe the passage of water into a plant. Using an apple corer, remove a section from the middle of the carrot. Be careful not to cut through the wall of the carrot. Obtain a 1-hole rubber stopper that will fit the



hole cut in the carrot. Wet the stopper and carefully insert the glass tubing beginning at the wide end of the stopper so that the tubing extends about ½ inch beyond the narrow end of the stopper. Pour molasses into the carrot, leaving enough room to insert the stopper. Then insert the stopper and tube into the carrot and support the carrot and tube in a jar, as shown in the illustration. Seal the stopper to the carrot with melted paraffin so that no leakage can occur. The paraffin can be applied with a small brush. Add water to the jar up to the top of the carrot.

Ask the children how they will be able to tell if water is entering the carrot. *(As the water in the jar enters the carrot the water mixes with the molasses, and the mixture rises in the tube.)* The children could measure the height of the water in the tube at intervals of several hours and record their results. At some point the water will no longer continue to rise in the tube. At this point the water is entering the root with a force just great enough to hold up the weight of the water–molasses mixture in the tube. This force is called osmotic pressure and is one factor in explaining how water enters the roots of a plant and rises through the stems to the leaves.

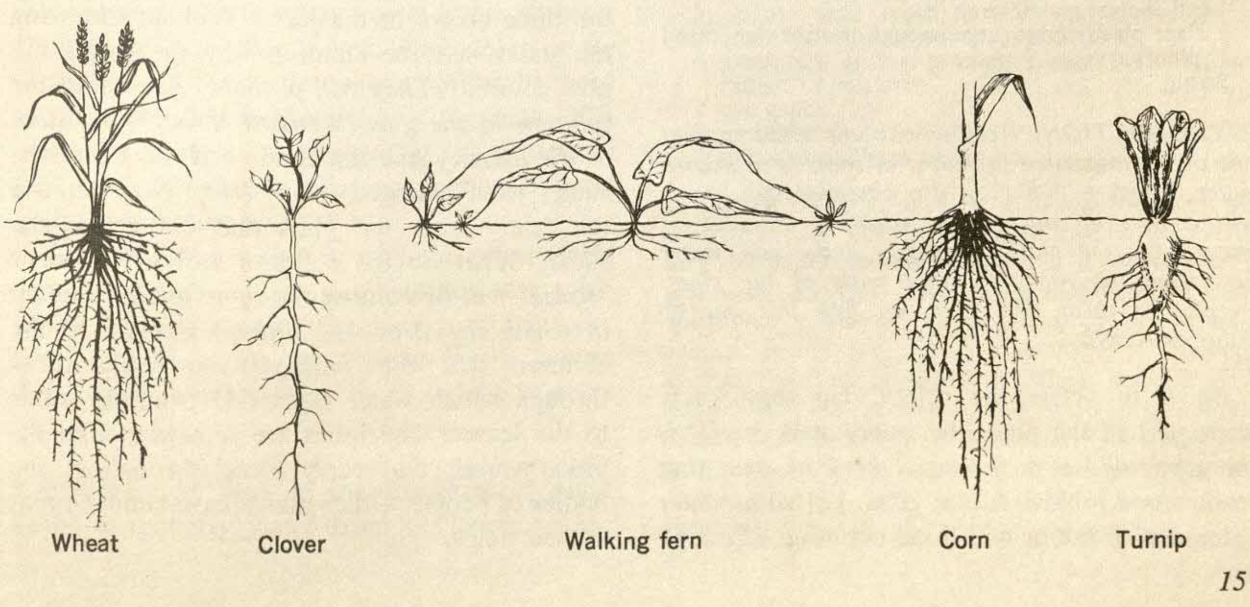
To study the structure of a root, the children may wish to carry out the following Activity. Obtain a shallow dish that can be covered with a sheet of glass and fit a piece of blotting paper at the bottom. Pour water into the dish, soaking the blotting paper, and then pour off the excess. Place several radish seeds on the moist paper, and cover the dish with the glass and place it in a dark warm place. Open the dish daily to let in air and to check the blotting paper to be sure that it remains moist. Add water if necessary to keep the blotting paper moist. After about a week, or when the roots are about 1 inch long, have the children examine the roots with a magnifying glass. Tiny root hairs should be visible. The water for the plant enters through these fine root hairs.



Learnings: (x) Water enters the plant through the roots. (y,z) The process by which water passes into the plants is called osmosis.

Additional Activities: As the plants take in water they also take in minerals needed for plant growth. The roots thus bring into the plant two vital materials needed for the plant to make food.

ROOT SYSTEMS



Wheat Clover Walking fern Corn Turnip

Many different kinds of root systems are found among plants to enable plants to survive in their environment. Have the children try to dig up several kinds of root systems. They will find that plants that live in areas with ample water have wide, shallow root systems while those that live in arid areas have deep root systems. In a later Activity they will find out that roots grow toward the water in the soil. The children may wish to draw a chart for the bulletin board showing the root systems of different plants, labeling the plant and describing the area where it grows.

Some plants use the root as a place for storing food. Many roots that are used to store food for the plants are used as food by humans. The carrot and the potato are examples of such plants. Have the children suggest other plants that store food in this way. The children may wish to make a bulletin board display of pictures showing roots that man uses for food.

ACTIVITY 7 (x,y,z)

STUDYING STEMS AND LEAVES

Purpose: To give the children an opportunity to study stems and leaves, two other major plant parts

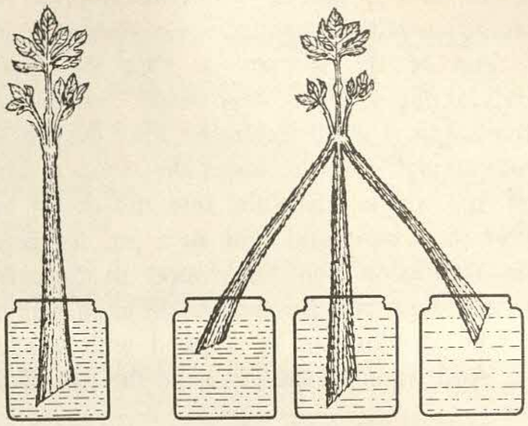
Concepts to be developed: Stems carry water from the roots to the leaves. Leaves retain some of the water, and they give off the excess water to the atmosphere.

Materials needed:

2 stalks of celery with yellow leaves
4 glass jars
Paring knife
Water
Ink or food coloring of three different colors (any colors except yellow and green are satisfactory)
2 leafy potted plants, such as geraniums
1 roll of clear plastic wrap
2 clear plastic bags large enough to hold the potted plants
String

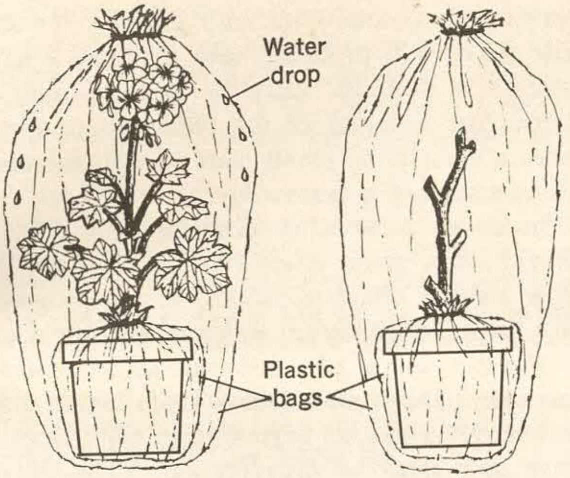
INTRODUCTION: Review with the children that one of the important functions of roots is to absorb water. Mention that they also observed that plants wilt if they do not receive adequate amounts of water. Ask the children if they know how water gets from the roots to other parts of the plant. Suggest to them that they can find this out by doing an Activity.

Show the class the celery. Do they know what part of the plant the celery stalk is? *(It is the stem, and it is a special kind of stem that stores food.)* Now fill a glass jar with water colored with ink or with food coloring. (Enough coloring should be added so that the water is a good strong color.) Cut diagonally across one stalk of celery near the bottom, and place the stalk in the jar containing colored water. Set the jar in bright sunshine.



Now make two cuts in a second stalk of celery, from the bottom of the stalk to within an inch or two of the top. The stalk will then be divided into three sections along most of its length, but the part that bears the leaves will be intact.

Fill each of three glass jars with water of a different color. (For example, one could be filled with purple water, the second with red water, and the third with blue water.) Place each section of the stalk in a different jar, and set the jars in the sunshine. In a few hours have the children look at the leaves. (The first stalk of celery will now have leaves that are the color of the solution in the jar. The second stalk will have leaves of three different colors, matching the three colors in the jars.) Without removing the stalks, ask the children why the leaves are now colored. *(They will probably guess that the solution in the glasses passed through the stalk to the leaves.)* Ask the children if the stem (the stalk) itself changed color. *(No.)* Now remove the celery from the glass and cut across the stalks. What do the children see? *(The celery "string" will be colored the same as the solution in which the stem was sitting.)* Explain to the children that the "strings" are really tubes through which water is carried from the roots to the leaves. The tubes are somewhat like the blood vessels that carry blood throughout the bodies of people. Other plants have similar tubes in their stems.



Now ask the children what they think happens to the water when it reaches the leaves. They will probably have many ideas about this. Suggest that they can do another Activity that will show them what happens to much of the water.

Show the children the potted plants. Remove all the leaves from one plant; the other plant should be left intact. Water both pots thoroughly. Then wrap clear plastic wrap around each pot, gather the material at the top, and tie it closely with string around the base of the stem. Now place each of the potted plants in a plastic bag, and tie the bag tightly at the top of the plant. Place both plants in a sunny spot.

Have the children examine the plants in an hour or two and ask them what they observe. *(They will see that moisture has collected on the inside of the bag around the plant with leaves. Little, if any, moisture will appear on the bag around the leafless plant.)* Ask the children where the water on the first bag came from. *(It must have come from the leaves, since there is no water around the leafless plant.)* What happens to the water that is absorbed by the roots of a plant? *(It is carried through tubes in the stem of the plant to the leaves. The leaves give off water to the surrounding air.)*

Some children may ask why the plant needs water. Through reading they will find that some of the water is used by the plant to make food. Food manufacturing takes place in the leaves. Water that is not needed by the plant is given off by the leaves.

Learnings: (x) One of the functions of plant stems is to carry water from the roots to the leaves. (y,z) The leaves use some water to make food. They give off excess water to the air.

Additional Activities: The children may enjoy repeating the first part of this Activity, using white carnations instead of celery. If it is near a holiday, the solutions could be colored appropriately, such as red for St. Valentine's Day, green for St. Patrick's Day, etc.

Some children might like to do another activity in which they will observe that leaves need air. Obtain a leafy potted plant, and cover two or three of the leaves on both sides with Vaseline. Place the plant in a sunny window and have the children observe it for about two weeks. Continue to water the plant with just enough water to keep the soil moist. At the end of the two weeks, have the children report what happened to the plant. *(The leaves that were covered with Vaseline at first turn yellow, and eventually they fall off. Leaves have air holes through which they take in air and give off water vapor. Vaseline clogs the air holes, causing the leaves to die because they cannot get air.)*

ACTIVITY 8 (y,z)

GROWING PLANTS WITHOUT SOIL

Purpose: To demonstrate that plants can be raised without soil, provided they receive certain nutritional elements

Concept to be developed: Plants cannot grow properly without certain nutritional elements that are usually obtained from the soil.

Materials needed:

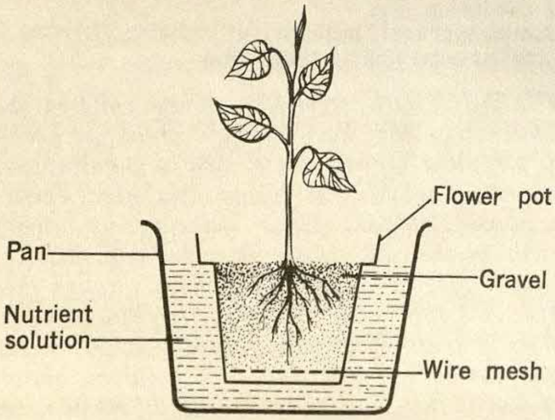
2 large flower pots
2 deep pans (almost as deep as the pots)
Gravel (enough to fill the pots)
2 square wire mesh screens (large enough to cover the opening at bottom of pot)
4 seedlings of fast-growing plants (oats, wheat, radish, or mustard)
2 one-gallon jugs
Commercial liquid fertilizer
Distilled water (from a drug store)

INTRODUCTION: Review with the children the conditions that they have already learned are necessary for plant growth (water and a suitable temperature). Explain that plants also need certain nutritional elements. These elements are usually present in the soil, where they become dissolved in water and are absorbed by plants through their roots. Ask the children what they think might happen if these elements are missing from the soil. If they do not know, explain that the plants become discolored, they wilt, their growth is stunted, and eventually they die.

Explain to the class that plants can take in these elements only when they are dissolved in water. (The elements are absorbed by the roots, then carried through the stem to the leaves.) Suggest to the class that it is possible to grow plants without any soil at all—by growing the plants in water that contains all of the nutritional elements they need. Ask the class how this method of growing plants might be of value. (One probable answer is that plants could be raised in places where there is no soil, for example, in a spaceship.) *This method of growing plants (called hydroponics) was also used in the South Pacific during World War II after many Americans became ill because their vegetables were grown in soil that was infested with disease-causing microorganisms. To prevent servicemen from becoming sick, their vegetables were grown without soil—in solutions of water and chemicals.*

Place a wire mesh screen at the bottom of each pot, and fill the pots with gravel. (This is to give support to the plants.) Carefully plant two seedlings in each pot, without damaging the roots, and then prepare two watering solutions. Into one jug pour the liquid fertilizer, diluted according to the directions on the label. (You may have a student read aloud the label of the fertilizer to see what the necessary nutritional elements are.) Into the second jug pour distilled water. (Rainwater that has been collected in a clean glass or plastic bowl may also be used.)

Place each flower pot in a deep pan, and water one pot with distilled water and the other with the liquid fertilizer. Let the liquid rise nearly to the rim of the dish. Let the pots stand for about 15 minutes. Then take them out, letting whatever liquid they still hold run into the dish below. Place the pots in a well-lighted part of the room. The watering solutions in the pans can then be poured back into the jugs for use later. (You will probably have to make a new solution of fertilizer once or twice a week.) Repeat the watering of the plants about three times a day. If the plants start to wilt, increase the watering to five times a day.



In about a week or ten days, the plants should show some changes. The class should then make a chart to record weekly progress. Ask them if they see any differences in the color of the two sets of plants. Is one set taller than the other? Does one set have more leaves than the other? Is one set beginning to wilt? Does it have any areas of discoloration? *(The plants watered with the fertilizer solution should be healthier in all respects.)* Ask the children if they know why these changes occurred. *(One set had the necessary nutritional elements and the other did not.)* The children can record their observations in a chart similar to the following:

Week	Plant watered with distilled water			Plant watered with fertilizer solution		
	Height	Number of leaves	Color	Height	Number of leaves	Color
1						
2						
3						
4						

Learnings: (x) Plants cannot grow without certain nutritional elements. Normally, plants obtain these elements from the soil, but they may obtain the elements directly from the chemically prepared water instead. Soil is not necessary to raise plants.

ACTIVITY 9 (x,y,z)

STUDYING LIGHT AND PLANT GROWTH

Purpose: To discover that green plants need light to grow properly and to remain green

Concepts to be developed: Light is essential for normal plant growth. When placed in the dark, green plants turn yellow because they do not manufacture the green pigment chlorophyll.

Materials needed:

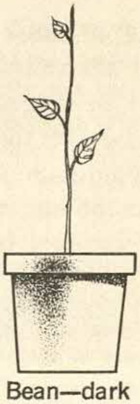
- Bean seeds
- Corn seeds
- Potatoes with "eyes"
- Flower pots
- Potting soil
- Dark closet or cardboard cartons
- Rulers

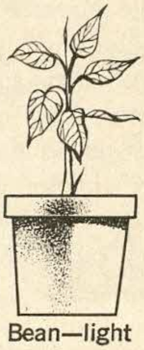
INTRODUCTION: Explain to the children that green plants derive their coloring from the green pigment, chlorophyll. This pigment is produced by plants in the presence of light, and it is used by plants to make food by the process called photosynthesis.

Ask the children what else green plants need to make food. (Carbon dioxide, water, and nutrients.) *What would happen to plants that did not have light?* (The children may answer that the plants will die from lack of food or that the plants will be small and shriveled.) *Explain that plants* will *grow in absence of light, but that their growth is not normal. Plants grown in the dark have long spindly stems. Their leaves are tiny and not developed, and the places along the stem where the leaves grow are spaced widely apart. Plants grown in the dark are also yellowish instead of green. This is because green plants need light in order to make the green pigment, chlorophyll. Suggest to the children that they can prove all of these things by performing an Activity using corn and bean seeds and potato. (If the children question these choices, tell them that the bean and corn seeds and the potato "eye" all contain sufficient food to allow considerable plant growth even if photosynthesis does not occur.)*

Have the children plant duplicate pots of corn seeds, bean seeds, and potato "eyes"; about three seeds or potato "eyes" per pot will insure examples of seed germination. The seeds should be planted about ½ inch deep in the soil and watered so that the soil is moist. Have the children label the pots *bean-light, bean-dark; corn-light, corn-dark; potato-light, potato-dark.* The bean-light will be where it will receive light, the bean-dark in the dark, and so forth. The plants that receive light will serve as a control and enable the children to observe what a normal plant looks like.

Place the light plants on a classroom window sill that receives light, and keep them there for the duration of the Activity. Place the dark plants in a closet. If a closet is not available, the dark plants can be kept in the room, but they must be covered with a cardboard carton that does not permit light to enter it. (Holding the carton over your head while looking at a light fixture is a good test to determine if any light enters the carton.) Both sets of plants should be watered as needed to keep the soil moist. The temperature of both locations should be about equal.


Bean—dark


Bean—light

In about two weeks the plants will have germinated and grown enough for observation. Place the corn-light and the corn-dark plants next to each other, the bean-light and bean-dark plants next to each other, and the potato-light and potato-dark plants next to each other. Ask the children what they observe. *(They should be able to see the following differences between the light and the dark plants: Light—green in color, stem sturdy, leaves developed. Dark—yellowish in color, long spindly stem, tiny leaves, places where the leaves grow widely spaced. If the leaves do not grow at all, these spaces may appear as bumps on the stem. If necessary, have the children measure the spaces between the bumps on the dark plants and compare them with the spaces between the leaves on the light plants.)*

Ask the children what they can deduce from this experiment. Do plants grow in the dark? *(Yes.)* Do plants grown in the dark grow normally? *(No.)* What do they look like? *(Long stems, tiny leaves, yellowish color.)* What can the children conclude from the appearance of a plant grown in the dark? *(Light is required for plants to grow normally.)* Ask the children what makes plants green. *(Chlorophyll in the leaf.)* If the dark plants are not green, what can the children surmise? *(Chlorophyll was not present in the leaf.)* The children may conclude that leaves manufacture chlorophyll in the light, but not in the dark.

Learnings: (x) Plants need light in order to grow properly and to be green. Plants grown in the dark have long spindly stems and tiny underdeveloped leaves, and are yellow in color. (y,z) Plants make chlorophyll, the green pigment, only in the presence of light. Plants do not make chlorophyll in the dark.

Additional Activities: Obtain a geranium plant and have the children cover one of the leaves with aluminum foil, a paper bag, or black paper. Place the plant on the window sill and water it once. (Geranium plants should be watered only when the stem starts to pull out of the soil.) After four days, remove the aluminum foil and observe the difference between the covered leaf and the exposed leaves. *(The covered leaf will be yellowish in color. Plants need light in order to carry out photosynthesis. Photosynthesis occurs in leaves.)*

ACTIVITY 10 (z)

OXYGEN PRODUCTION DURING PHOTOSYNTHESIS

Purpose: To show that oxygen is produced during photosynthesis

Concept to be developed: During the process of photosynthesis plants produce oxygen.

Materials needed:

- Bunch of elodea or other aquatic plant
- Battery jar (or 1-gallon wide-mouth jar)
- Funnel
- Test tube
- Stand to hold test tube in inverted position
- Splints
- Matches

INTRODUCTION: Review with the children the factors necessary for photosynthesis. Remind them that plants need light, water, and carbon dioxide in order to make food. Explain that during this food-making process, plants also produce the gas oxygen. Suggest to the class that the following Activity concerns photosynthesis and that they will be able to see that oxygen is produced.

Fill the battery jar with water, and place the plants in the center of it. Cover the plants with the funnel inverted, making sure that the top of the funnel does not extend beyond the surface of the water. Fill the test tube with water, and place it over the opening of the funnel. Attach the test tube to the stand so that it is held erect. Be careful not to allow any air in the test tube.

Place the whole set-up in a sunny place for a day, and then have the children describe what happened. *(At the top of the test tube is a space that was not there the previous day.)* Call their attention to the tiny bubbles floating up in the test tube and ask them what these bubbles might be. *(Bubbles of oxygen.)* If they cannot see the bubbles ask them what the space at the end of the test tube may be filled with. *(Oxygen.)* Where did the oxygen come from? *(The plant.)* How was the oxygen produced? *(It was produced during photosynthesis.)*

Suggest to the children that they test to see if the space is filled with oxygen. Explain that this can be done by inserting a glowing splint into the test tube and watching to see if the glowing splint bursts into flame.

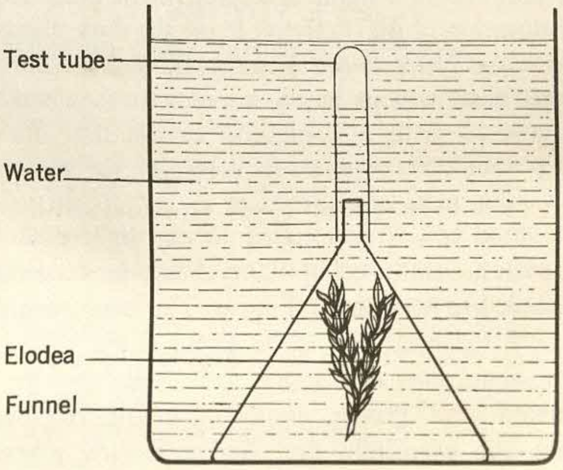
Carefully remove the test tube—the water in it will run out—and quickly stick a glowing splint in it. Be sure that you are still holding the test tube upside down and that the splint reaches the top. Ask the class to describe what happens. Why does the glowing splint burst into flame? *(Because oxygen is present.)* Where did the oxygen come from? *(The plant.)*

Learning: (z) During photosynthesis, water plants (as well as land plants) give off oxygen. One way of testing for oxygen is to see if a glowing splint will burst into flame.

Summing Up Ideas: In this section the children learned some of the characteristics and needs of plants. They found out about the structure of seeds and the factors which affect seed germination. They saw that water is taken on by the roots and transported to the leaves by the stems, where food is made in the presence of light and chlorophyll. Photosynthesis, the process by which the food is made, results also in the release of oxygen.

WHAT ARE THE CHARACTERISTICS OF NONGREEN PLANTS?

When studying or talking about plant life, children commonly think only of green plants. However, nongreen plants are found all around us and have a great influence on our daily lives.



Among the most common nongreen plants are bacteria, molds, yeasts, and mushrooms. All nongreen plants lack the green pigment chlorophyll. As a result, nongreen plants cannot manufacture food, but must obtain their food from their environment. The source of their food is either other living organisms or decaying organisms. Nongreen plants also differ from green plants in their method of reproduction. Most green plants bear flowers and reproduce by seeds. Nongreen plants reproduce by other means. One such method, spore formation, will be observed in Activity 14.

Some nongreen plants are harmful to man. Among these are many kinds of bacteria, which cause diseases such as tuberculosis, lockjaw, whooping cough, pneumonia, and tonsilitis. Other kinds of bacteria cause food to spoil. Food spoilage, particularly of fruit and bread, may also be caused by mold.

Although many nongreen plants are harmful, many of them are useful. Some bacteria live in the soil, where they cause the rotting of dead plants and animals. This adds nutrients to the soil and helps plants to grow. Other bacteria are helpful because they produce certain substances that are useful to man. Bacteria that produce acetic acid are used to make vinegar from alcohol. Other kinds of bacteria are used in making yogurt and cheese.

Yeasts are important in the baking and brewing industries because they produce carbon dioxide and substances that change sugars into alcohol. Yeasts are also sometimes used as a source of vitamins. Some molds are also valuable to man. The antibiotic penicillin, for example, is produced by a mold.

ACTIVITY 11 (x)

STUDYING CONDITIONS NECESSARY FOR THE GROWTH OF BREAD MOLD

Purpose: To observe and study the growth of molds, a major group of nongreen plants

Concept to be developed: Molds grow best in warm, dark places.

Materials needed:

4 sterilized Petri dishes
1 slice of moldy bread
1 slice of fresh bakery bread cut into 4 equal pieces (kept covered until used)
4 cotton swabs
Thermometer
Medicine dropper

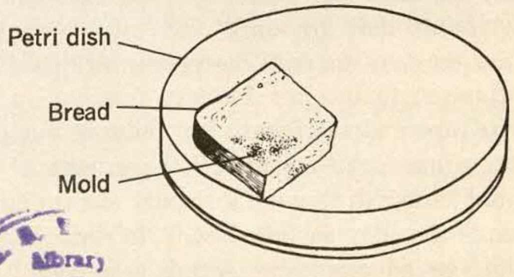
INTRODUCTION: Since children commonly think only of green plants when they study or talk about plant life, introduce the idea that there are also some nongreen plants. These are found all around us and have a great deal of influence on the way we live. Have the children tell what they know about molds. Almost every child has seen mold, a velvety, cobweb-like growth, growing on bread, and many of them have also seen mold in opened jars of jam or cans of fruit. Explain to them that molds are saprophytes, *that is, they cannot make their own food but live on other matter. Put this new term on the chalkboard to add to the children's science vocabulary. Ask the children what is done with most moldy food. Point out that it is usually thrown out because, although the mold would probably not have caused serious illness, the food would have a disagreeable taste.*

Ask the boys and girls under what conditions they have seen mold growing. Suggest that a good way of determining the best conditions is to try growing molds. This way, they will see for themselves which conditions are most suitable.

Sterilize the Petri dishes by washing them with a strong detergent and then heating them with their covers in place in an oven at 400° F. for about one hour. Remove the dishes from the oven carefully, keeping the covers in place.

The bread mold to be used may be obtained in one of two ways. A child may bring in a piece of moldy bread from home, or the children may prepare it themselves by exposing a moist piece of bread to the classroom for about an hour. (It should be explained that homemade bread or bread made by a small bakery is best for this Activity because packaged commercial breads contain chemicals that inhibit the growth of molds.) The bread is then put in a warm, dark, damp place for about four days. When the mold is black, it is ready for use.

Have the children uncover the Petri dishes and place a piece of fresh bread in each one. Caution them not to expose the bread to the air for too long (to prevent contamination). Using



Date 9.8.05
Accn. No. 1177

Library

the medicine dropper, have one child place ten drops of water on each piece of fresh bread. Then, using a different swab of cotton for each dish, dust a small amount of the mold from the moldy bread on the bread in each dish. Place the lids on the Petri dishes, and put them in four different places. One dish can be put in a cold dark place, such as a refrigerator. Another can be put on the window sill exposed to the sun's rays. The third may go any place in the classroom where it receives some light but is not exposed to the sun's rays and where it can be kept at room temperature. The fourth may be put in a warm dark place, such as a closet or a locker. The children can then make a chart on which they can record their observations and the daily temperature recordings. They should note the amount of growth, and the color of the mold. (The molds may assume various shapes, have various colors, and have an unpleasant odor.)

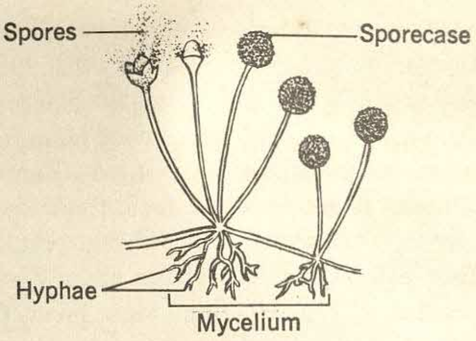
Ask the children why it was necessary to use the same amount of water in each dish, why portions of the same mold were planted in the dishes, and why the same kind of bread was used in each dish. *(Some of the conditions had to be the same so that they could know how the variable conditions—light and heat—affected the growth of the mold. Explain that this was how the experiment was controlled. All the conditions were the same except for the amounts of light and heat.)*

Did the plants grow better in the location where they had more heat? *(Yes, because in the cold places the plants' life processes were slowed down.)*

Did the plants grow better in the location where they had more light? *(Probably not, because since they are not green plants, they do not make their own food through photosynthesis, and hence do not need light.)*

Learnings: (x,y) Bread mold grows best in places that are dark and warm. (x,y) It does not grow in places that are dark and cold. (y) Bright sunlight does not help the growth of bread mold.

Additional Activities: If the children would like to see how moisture affects the growth of bread mold, suggest that they repeat the experiment using dry or toasted bread. In this case, the moist bread should be used as a control.



Some children may want to look for mold growing on other kinds of food. (Fruit that has been kept too long may have a different kind of mold, consisting of a white fuzzy growth.) The children may want to experiment with it as they did with the bread mold.

The children may want to examine a mold more closely by studying it under a magnifying glass or a microscope. Suggest that they use the bread mold for this. They should be able to see tiny thread-like structures, called *hyphae*, forming a network, called the *mycelium*. They will note that the velvety surface of the mold consists of many tiny spore cases borne on slender stalks. Explain that molds reproduce by means of *spores*. Each spore, if it settles in the proper environment, will develop into a mold. Ask children what are some of the necessary conditions for mold growth. Have the children record their findings by making drawings of the various kinds of molds they see through the microscope.

ACTIVITY 12 (y,z)

OBSERVING THE GROWTH OF BACTERIA

Purpose: To familiarize the children with bacteria, another major group of nongreen plants

Concept to be developed: Bacteria are microscopic nongreen plants that are present everywhere.

Materials needed:

5 sterilized Petri dishes containing nutrient agar (obtainable from a science supply house)
Marking pencil or crayon

INTRODUCTION: Ask the children if they know what the smallest known plants are. Explain to them that the smallest plants are microscopic nongreen plants called bacteria.

Do the children know where bacteria live? Encourage their theories and then explain that bacteria live everywhere—in the air, in the water, in the soil, even on, and inside, the children's bodies. Ask the children if they know why it is important to wash their hands before eating. The children should *be able to state that washing their hands helps to remove bacteria. Suggest to the children that the following experiment will prove to them that bacteria live everywhere.*

It is probably best to obtain prepared, sterile Petri dishes containing nutrient agar from a scientific supply house. However, they can be prepared at home if you have a pressure cooker.

Wash the Petri dishes with detergent and allow them to dry. Then place the covers in position and sterilize the covered dishes in the oven by heating at a temperature of 400° F. for about one hour. Remove the dishes and set them aside to cool keeping the covers in place.

Buy prepared dehydrated nutrient agar from a supply house. Mix with water according to the directions on the label. Heat, stirring constantly, until the mixture comes to a boil. Pour into a Pyrex flask that will fit into your pressure cooker and plug the mouth of the flask loosely with absorbent cotton. Place the flask in the pressure cooker and add water to the pressure cooker to provide steam for at least 30 minutes. Close the pressure cooker and cook at 15 pounds of pressure for 15 to 20 minutes. Allow the pressure cooker to cool; then open and remove the flask. Allow the flask to cool slightly but not enough for the agar to gel.

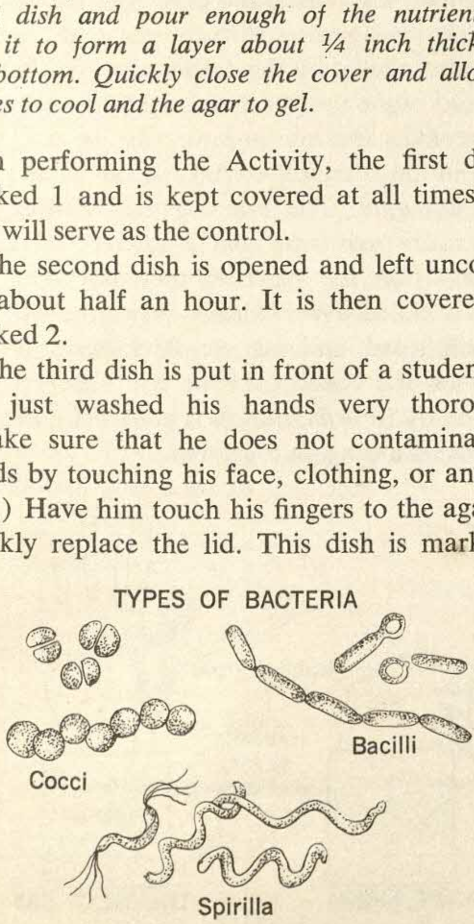
Carefully lift one side of the cover of each sterile Petri dish and pour enough of the nutrient agar into it to form a layer about ¼ inch thick over the bottom. Quickly close the cover and allow the dishes to cool and the agar to gel.

In performing the Activity, the first dish is marked 1 and is kept covered at all times. This dish will serve as the control.

The second dish is opened and left uncovered for about half an hour. It is then covered and marked 2.

The third dish is put in front of a student who has just washed his hands very thoroughly. (Make sure that he does not contaminate his hands by touching his face, clothing, or anything else.) Have him touch his fingers to the agar and quickly replace the lid. This dish is marked 3.

TYPES OF BACTERIA



The fourth dish is given to a child who has not washed his hands. Have him touch his fingers to the agar and quickly cover the dish. This dish is marked 4.

The fifth dish is given to another child. Have him open the dish and comb his hair over it. This dish is then quickly covered and marked 5. Have one child keep a record such as that shown below.

Dish number	Treatment	Description of dish after 3 days
1	None	No growth
2	Uncovered in air	
3	Touched by clean fingers	
4	Touched by dirty fingers	
5	Hair combings added	

All five dishes (covered) are then put in a warm dark place for about three days. (Be sure to keep tops on all dishes.) Do not allow the children to touch, sniff, or in any way come into contact with the contents of the dishes.

When the cultures are ready, the children should examine them and note which contain larger colonies of bacteria. (All of the dishes may contain bacteria colonies. Dish 1 should have the least growth; it may not have any at all. Dish 2 should have some growth. Dish 3 should have some also, but less than dish 4. Dish 5 should have considerable growth.) Ask the class how the first dish served as a control. *(It was prepared the same way as the other four, but was not exposed to bacteria as the others were.)*

(Be sure to dispose of all cultures after this Activity is completed. First flood the surface of each dish with Lysol, or a 5% solution of cresol. Let the solution stand for about half an hour and pour off. Empty the dishes into a newspaper, and burn it in an incinerator. Do not touch cultures. Wash dishes in a strong detergent as a further safeguard.)

Learnings: (x) Bacteria are present everywhere. (x) Many of the bacteria present on a person's hands can be removed by thorough washing.

Additional Activities: The children may want to look for bacteria in other places. They can grow bacterial colonies by placing Petri dishes containing sterile agar out-of-doors and having a child sprinkle some dust into a dish.

With some children you may want to try cultivating bacteria colonies under varying environmental conditions. This can be done by exposing prepared Petri dishes to places where the children think bacteria exist and then placing the dishes in different places. One dish may be put in a cold dark place, such as a refrigerator. Another may be put on a window sill in direct sunlight. A third dish may be placed on a desk away from direct sunlight, and a fourth dish may be kept in a warm dark place. After several days, the children can conclude that the warm dark place is best for growing bacteria.

ACTIVITY 13 (y)

OBSERVING THE GROWTH OF YEAST

Purpose: To familiarize the children with yeasts, another major group of nongreen plants

Concepts to be developed: Yeasts are tiny nongreen plants and, like other nongreen plants, do not make their own food. When yeasts feed on sugar, in the absence of air, they form carbon dioxide gas and alcohol, in a process known as "fermentation."

Materials needed:

Cakes of yeast
Measuring cup
2 jars
Rubber glove
Sugar
Water
Tablespoon

INTRODUCTION: Pass a cake of yeast around the class and have the children examine it. Tell the class that this cake consists of many tiny nongreen plants called yeasts. Tell the class that yeast plants are so small that they can be seen only with a microscope. Under the microscope, yeasts are seen as one-celled nongreen plants.

Explain to the class that of course the yeast plants do not grow in cake form. The cake is a commercially prepared product that has been formed into a shape convenient for use in baking. Tell the children that yeast does grow and reproduce. Ask them if they think that the yeast cake is growing or reproducing. Ask them why they think it isn't growing. To help them think about the questions, ask the children where yeast is kept in the grocery store, and what effect this has on the yeast. From this the class should be able to deduce that the yeast cake is not growing because it is kept in the refrigerator, where the colder temperatures slow down growth.

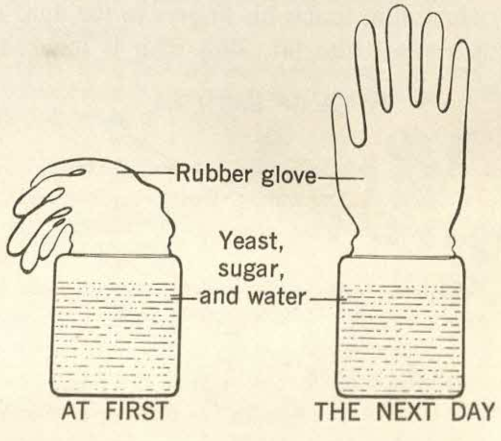
Do the children know what yeast is usually used for? Suggest that in baking, the yeast makes dough "rise." Why does yeast make dough rise? The following Activity will show them the answer.

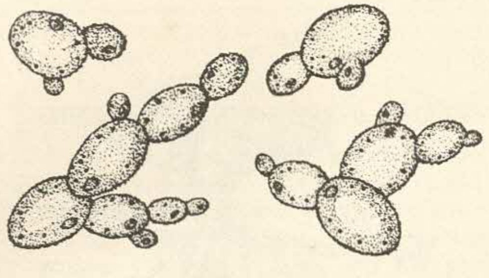
Have a student crumble a yeast cake and dissolve it in a glass of water. Warm water should be used if it is available. Have another student prepare a sugar solution by dissolving about 4 tablespoons of sugar in about 2 cups (16 ounces) of water. Be sure that all the sugar and yeast are dissolved.

Into each of two jars pour about half the yeast solution and about 1 cup of the sugar solution. Stir each mixture well. Cover one of the jars with a piece of cardboard. Fasten the rubber glove tightly over the mouth of the second jar, holding it in place with a rubber band. Leave both jars in a warm place for one day. Yeast must be warm in order to grow and react with the sugar.

The next day have the class examine the jars. *(The solution in each jar should be cloudy and have rising bubbles. The rubber glove should be inflated.)* Explain to the class that the bubbles in the jar are carbon dioxide gas and that the glove was inflated by the carbon dioxide that was produced when the yeast reacted with the sugar.

Have the class uncover the first jar and sniff the solution carefully. Ask them what they smell. *(Alcohol. The brewing and distilling industries use yeasts to make alcohol.)* Remind the class that the reaction they have just observed is called *fermentation.* Write the word on the chalkboard, and ask a child to write its definition on the board after he has checked it in a dictionary. *(Fermentation is caused by the tiny yeast plants during their growth.)*





Yeast Cells

Some children may ask what happens to the alcohol and carbon dioxide during the baking process. During the baking process, the alcohol evaporates. The carbon dioxide produces bubbles that remain in the bread dough as the "air holes" that make bread spongy.

Learnings: (y) Yeast reacts with sugar to produce a gas (carbon dioxide) and alcohol. This process is called fermentation. Fermentation is the process that causes dough to rise. It is also the process used to make alcohol.

Additional Activities: Have the class mix a solution of sugar and yeast and then add enough flour to make dough. Place the glass in a warm part of the room, and have the class observe the glass a few hours later. *(The dough will have risen because the carbon dioxide given off by the yeast is trapped inside the dough.)*

If a microscope is available, have the class remove a few drops from the yeast–sugar solution after fermentation has occurred and place them on a glass slide. Cover the slide with a cover slip and examine it under the microscope. *(The children will see that yeasts are one-celled and are not green.)* Have a few children draw pictures of what they see and describe the appearance of the yeast to the class.

ACTIVITY 14 (y,z)

DETERMINING HOW MUSHROOMS LIVE AND REPRODUCE

Purpose: To help children discover the reproductive structures of mushrooms, a major group of nongreen plants

Concept to be developed: Mushrooms are nongreen plants that produce new plants like themselves by means of tiny structures called "spores."

Materials needed:

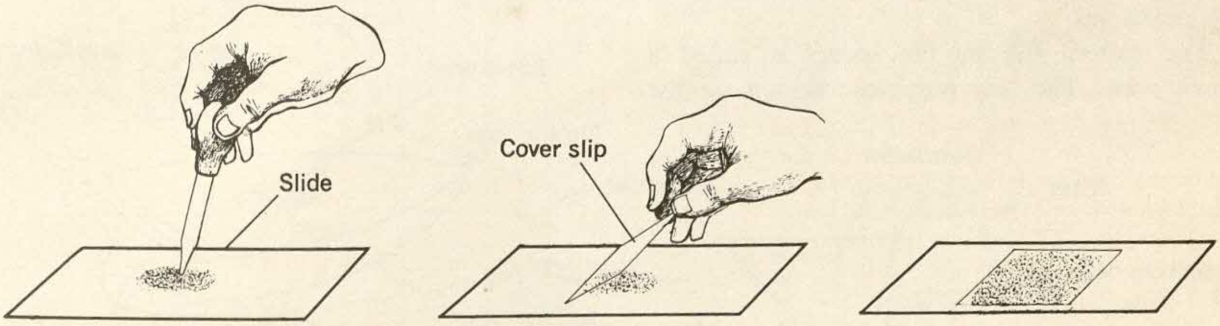
Mushrooms (fresh, preferably obtained from a grocer)
Knives
Sheets of white and black paper
Wide-mouthed tumblers or glass candy dishes

INTRODUCTION: Ask the children if they have ever seen mushrooms and ask them to describe them. Have any of them ever seen a green mushroom? Explain that this would be impossible because mushrooms are nongreen plants and do not contain chlorophyll.

Review with the children what they remember as being the most important distinction between green and nongreen plants: the fact that nongreen plants do not make their own food. Then ask them how mushrooms obtain their food. Encourage their theories. Ask the children, as a clue, to consider where mushrooms grow. Explain to the children that mushrooms get their food from the dead organisms on which they are found growing in fields and other places.

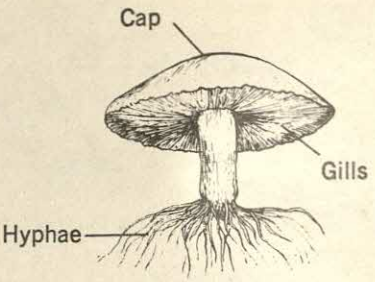
The children will know that the mushrooms they can buy from the grocer are edible. Caution the children that many mushrooms that grow wild are poisonous. These mushrooms are commonly called toadstools. Emphasize that they should never taste or handle mushrooms that they find in the field.

Explain to the children that mushrooms, like all living things, reproduce. But did anyone ever hear of a mushroom seed? Explain that mushrooms do not produce seeds. The following Activity will show the structures by which they reproduce.



Making a Slide to Observe Yeast Cells

Distribute a number of mushrooms to the class and have the children examine them. (Instruct them to be careful and gentle, as mushrooms break easily.) Tell them that the umbrella-shaped top is called a cap and the rest of the plant the stalk. The cap is the reproductive organ, and the stalk supports it. The part of the plant concerned with obtaining food and water grows below the ground. Only the reproductive part grows above ground. Discuss how this adaptation helps spread the species.

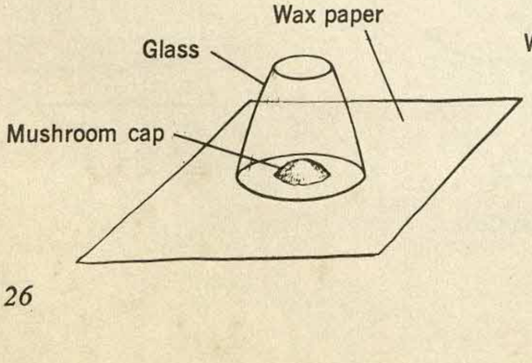


Have the students cut the stalk close to where it joins the cap and turn the cap over. On the underside of the cap the children will see numerous, thread-like structures that are arranged like the spokes of a wheel. These structures, called *gills,* produce the tiny spores that grow into new mushroom plants. Explain to the children that spores are not usually seen because they are so tiny and because the wind blows them from the plant. The spores serve the same function as seeds do. It can be added that mushroom plants "spread" through an area by means of the spores.

Distribute other fresh mushrooms to the class, and have the children gently cut the cap from the stalk as before. Have them place the caps, rounded side up, gill side down, on pieces of wax paper. Have each child cover his mushroom cap with a wide-mouthed tumbler or a glass candy dish. The glass will prevent the spores from being blown away. Leave this arrangement undisturbed until the next day.

The next day have the class remove the glass covering and gently lift the mushroom cap. Upon examining the wax paper beneath the cap, the children will find a powdery pattern. Some children may find whitish, black, purplish, or brown spores. If they question this, explain to them that different kinds of mushrooms produce different colored spores.

The pattern left by the spores is called a *spore print.* The tiny particles making up the print are the spores. The pattern is determined by the arrangement of the spore-producing gills on the underside of the cap. To make their spore prints permanent, the children may heat the wax paper with an iron set on low. The spores will settle into the melting wax. Each print may then be mounted on colored construction paper for contrast. For example, white spore prints will show up nicely on black or purple construction paper.

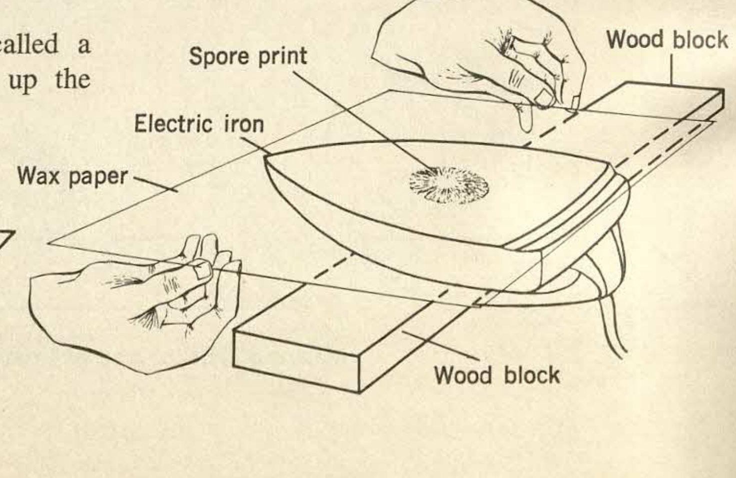


Learnings: (x) Mushrooms, like other nongreen plants, obtain their food from other organisms. They do not make it themselves. (y,z) Mushrooms reproduce by making tiny bodies called spores, each of which can grow and develop into a new plant like its parent.

Additional Activities: In rural areas: Arrange a field trip to observe mushrooms in their natural habitat. In urban areas: Plan a trip to a botanical garden to see cultivated mushrooms.

Summing Up Ideas: In this section the children learned that nongreen plants do not make their own food but obtain it from their environment. They learned some of the conditions necessary for the growth of molds, bacteria, yeasts, and mushrooms. All these require warmth, moisture, and food in order to grow well and to reproduce.

Making a Spore Print Permanent



IMPORTANT IDEAS IN THIS CHAPTER

For the kindergarten, primary-grade, and intermediate-grade children, the ideas with the most meaning and application are these:

- All plants are generally divided into two groups: the green plants and the nongreen plants.
- Most green plants make their own food and most nongreen plants do not.
- Green plants contain chlorophyll.
- A seed consists of a protective coat, an embryo plant, and stored food.
- Seeds require both water and air to germinate.
- Soil is not required for the germination of seeds.
- Seeds require a suitable temperature in order to germinate.
- Different kinds of seeds will germinate at different depths.
- Seeds will not germinate at temperatures below freezing.
- Stems carry water from the roots to the leaves.
- Leaves give off water into the air.
- Leaves have holes in their surfaces through which they take in air and give off water vapor.
- Plants require nutritional elements in addition to water in order to grow.
- Green plants require light in order to grow properly and carry on photosynthesis.
- Plants require light in order to make chlorophyll.
- Oxygen is produced during photosynthesis.
- Water enters a plant through roots.
- Among nongreen plants are bacteria, mold, yeast, and mushrooms.
- Mushrooms reproduce by means of spores.
- The spores of bread mold are nearly everywhere. They will grow when they come into contact with moist bread.
- Bread mold grows best in places that are dark, warm, and moist.
- Bacteria are very small nongreen plants.
- Bacteria are almost everywhere.
- Many bacteria can be removed from a person's hand by washing.
- Yeasts are tiny nongreen plants.
- Yeasts feed on sugar.

In addition to these ideas, in the intermediate and upper grades the children should be led to develop concepts that are more complex.

- Photosynthesis is the process by which green plants, in the presence of chlorophyll, make food using water and carbon dioxide.
- Nongreen plants obtain food from their environment, which may be living or dead plants or animals.
- The energy for photosynthesis comes from light.
- If a seed is planted at too great a depth, it will germinate, but the plant will die because the new plant will use up its stored food before it reaches the surface.
- Plants can be raised without soil if they are provided with nutritional elements and water.
- The root structure through which water is absorbed is the root hair.
- Water enters into the plant by the process of osmosis.
- Yeasts react with sugar in the absence of air to form carbon dioxide and alcohol. The process is called fermentation.
- The "holes" in bread result from bubbles of carbon dioxide gas produced when the yeast reacts with the sugar in the dough.

3

INVESTIGATING THE CHARACTERISTICS AND NEEDS OF ANIMALS

It is estimated that there are probably several million different kinds of animals living today. These animals range from microscopic one-celled organisms, called protozoa, to large complex mammals. Animals that lack backbones are called invertebrates. Well-known invertebrates include insects, earthworms, spiders, lobsters, and shellfish. Animals with backbones are called vertebrates. Mammals, such as the dog, cat, hamster, horse, and man, make up the most familiar group of vertebrates. One large group of vertebrates consists of the birds. Other large groups of vertebrates are the fish and the amphibians (including the frog).

All the members of a group have many characteristics in common. All birds, for example, have feathers and lay eggs. All mammals have hair on their bodies, nurse their young, and breathe by means of lungs.

Like plants, animals cannot survive without a suitable environment. Such an environment must include an adequate supply of food and water. Although green plants manufacture their own food, animals cannot. Instead, animals must obtain their food materials by feeding on plants or on animals that have eaten plants. Most animals also differ from plants in that they are able to move about freely while plants stay in one place.

ACTIVITY 15 (x,y,z)

OBSERVING AND IDENTIFYING BIRDS

Purpose: To observe and identify neighborhood birds

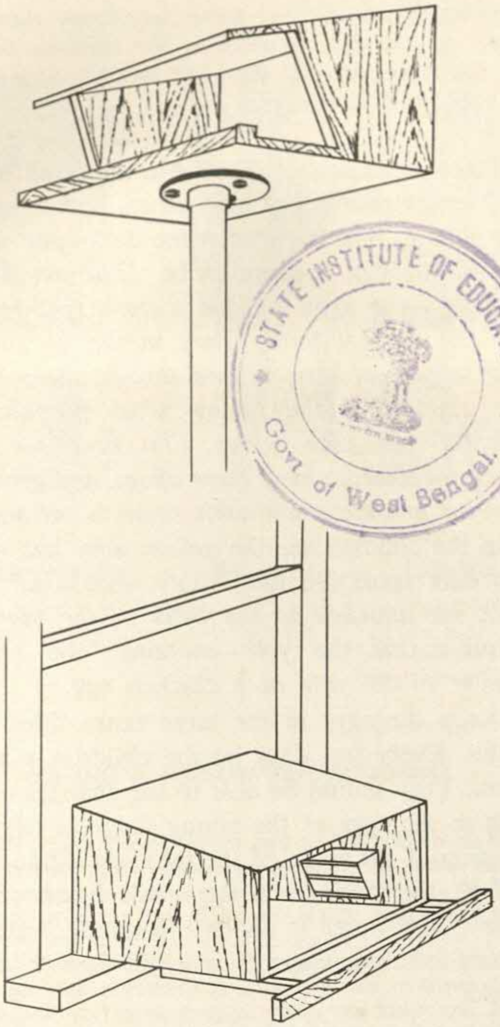
Concepts to be developed: There are many kinds of birds. Birds can be identified by their size, shape, and color.

Materials needed:

- Wood and tools to make bird feeder or a ready-made feeder
- Shallow pan
- Gravel (about 2 cups)
- Bird seed
- Meat scraps
- Cracked nuts
- Bread crumbs
- Rolled oats
- Sunflower seeds
- Pieces of apple
- Field manual of birds or a bird watcher's guide

INTRODUCTION: Ask the children what kinds of birds they have seen in their neighborhood. Encourage them to name and describe some of the birds. Explain to the children that birds are identified not only by their characteristic color and marking, but also by their shape and size. Suggest to the children that they can discover and learn to identify many birds in their neighborhood by building a feeder, a platform on which the food can be placed for birds to eat. Have the children suggest different kinds of food to be placed on the feeder, such as seeds, grains, insects, fruit, or meat scraps. Mention that birds also need water. Have the children place a pan of water with the food.

Have the children construct the bird feeder or set up the ready-made feeder. If the school has a yard, the feeder can be set up on posts in the yard. The base of the feeder will serve as a platform for the food and the water. The two pieces of wood on the sides of the base will support a roof that protects the food and water from rain and sun. The wooden rod attached to the supporting planks is used as a perching rail. If the school has no yard, the feeders can be set up outside the classroom window. In this case, fasten the platform of the feeder to the window sill instead of to the wooden posts.



STATE INSTITUTE OF EDUCATION Govt. of West Bengal

Simple Bird Feeders

After the feeders are in place, have the children scatter an assortment of food on the platform. (Scattering the food will permit many birds to eat at once rather than a few at a time as would occur if the food were in a heap.) Have the children set up the bird bath by placing gravel at the bottom of a shallow, water-filled pan.

Have the children observe the feeder for half an hour or so each day for two weeks. While they are doing this, the children can consult a field manual to learn to identify the birds that come to the feeder. They should note that birds not only drink water, but also use it to clean themselves. Ask the children if they can tell which birds ate what kind of food. *(Sparrows, finches, grosbeaks, cardinals, and juncos, for example, are seed eaters; birds, such as woodpeckers, jays, chickadees, and nuthatches, are insect eaters.)* From their observations children should discover that different birds eat different kinds of food.

Learnings: Birds eat different kinds of food. They drink water and use it to clean themselves. There are many different kinds of birds in a neighborhood. They can be identified by their coloring, shape, and size.

Additional Activities: Some children may enjoy observing the feeding habits of birds that are more selective in their choice of food. (For example, hummingbirds are attracted to the sweet nectar of brightly colored flowers. Set up the activity by dissolving sugar in water. Pour this solution into a jar and add red food coloring. Place the jar on the window sill.) By checking the field manual, the children can discuss other birds, such as eagles and gulls, that also have special diets.

If possible, leave the bird feeder set up permanently. Throughout the year have the children observe the kinds of birds that frequent the feeder. By consulting the field guide and identifying the birds, the children will be able to determine which kinds of birds in their area migrate. (Some kinds of birds will be at the feeder only at certain times of the year.)

ACTIVITY 16 (x,y)

HATCHING FROG EGGS

Purpose: To acquaint the children with reproduction in amphibians

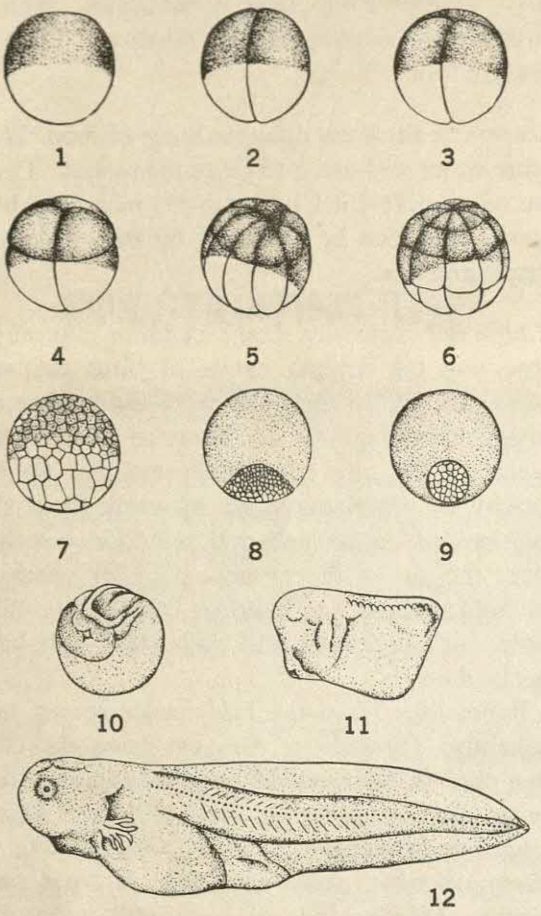
Concepts to be developed: Young frogs (tadpoles) change into adult frogs by a process called metamorphosis. Metamorphosis occurs in all amphibians.

Materials needed:

- Masses of frog eggs (obtained from ponds, streams, or purchased from a biological supply house)
- Large tanks (aquariums)
- Large tanks set up as terrariums
- Magnifying glasses
- Thermometer
- Small bowls
- Adult frogs

INTRODUCTION: Display the frog eggs to the class, and ask the children to describe them. Have the children notice that the eggs are round, small, stuck together in large masses, and composed of a clear jellylike substance surrounding a dark spot that is yellowish on the bottom.

Encourage the children to describe what the young frogs will look like when they hatch. Some



Stages in the development of a frog egg into a tadpole. The time required for this development to take place depends on the species and the water temperature. Below, an adult pickerel frog, common in many ponds.

may say tiny frogs, but some may know that they hatch as tadpoles. Explain to the children that in the following Activity they will be able to see tadpoles hatching from eggs.

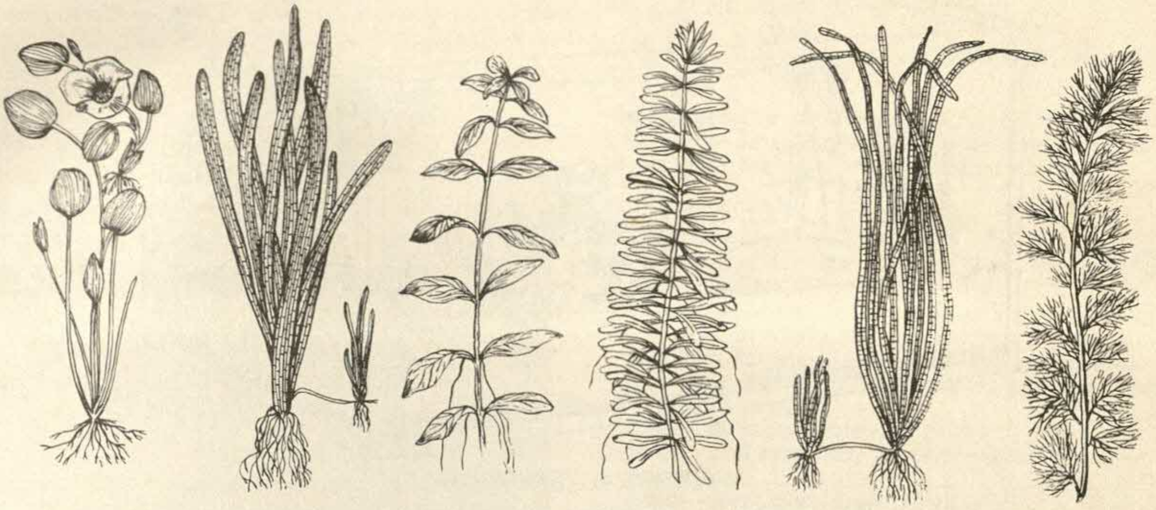
Place small masses of eggs in the small bowls, and let the children examine them with magnifying glasses. Ask them what the dark spot on the top of the egg appears to be. *(The developing tadpole. Any eggs without a dark spot toward the top are not fertile; they should be cut out with a pair of scissors and thrown away.)* Ask the children if they know what purpose the jellylike substance serves. *(To keep the eggs stuck together, to keep them afloat, and probably also to provide them with some nourishment.)* Can the children see the yellow area just under the dark spot? Do they know what it is? *(The yolk sac attached to the belly of the tadpole.)* Explain that the yolk contains food and is similar to the yolk of a chicken egg.

Keep the eggs in the large tanks filled with water. Every few days let the children examine them. They should be able to see changes occurring in the eggs as the young tadpoles begin to develop. If the water of the tank is kept at about 60° F. to 65° F., the eggs will hatch sooner than if the water is cooler. Normally, hatching should take anywhere from eight days to a few weeks.

When the eggs finally hatch, have the children examine and describe the tadpoles. *(Streamlined, fishlike body, no legs, long tail, gills in the neck region, beaklike mouth, dark brown or black body, etc.)* Display the adult frogs and ask the children what changes the tadpoles will have to undergo in order to become adult frogs. *(Lose the tail, grow hind legs and forelegs, change color, lose gills, which change to lungs for breathing, etc.)* Tell the children that these changes occur as part of a process called metamorphosis, and explain that all amphibians undergo metamorphosis. (Another familiar amphibian is the salamander.)

Ask the class to identify the yellow pouch attached to the tadpole's stomach. *(The yolk sac.)* Ask them if the tadpoles will need food right away. *(No, because they have not used up the entire supply in the yolk sacs.)* Tell the class that the tadpoles should be able to live for another few days without needing additional

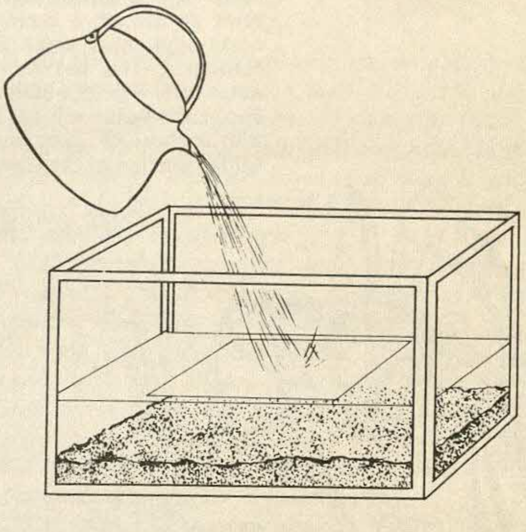
PLANTS FOR THE FRESHWATER AQUARIUM

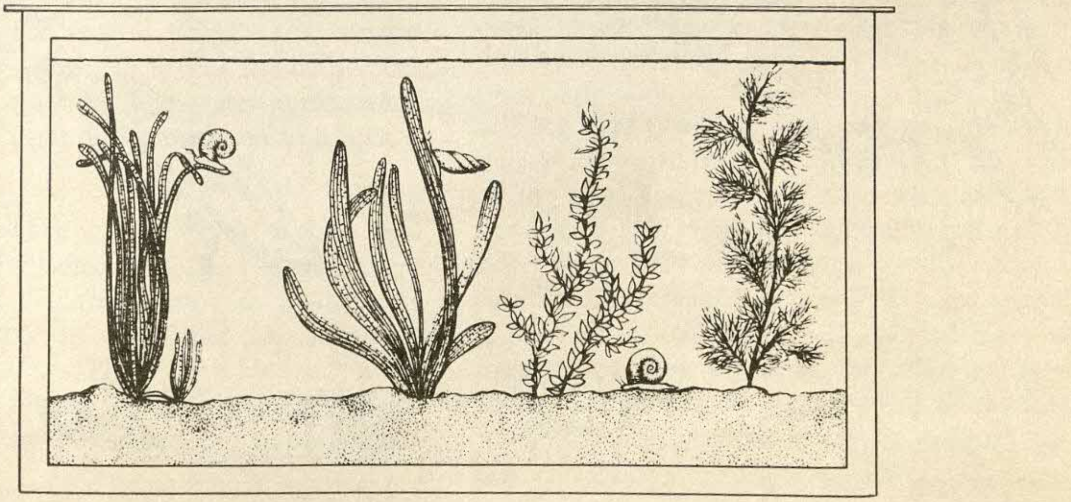


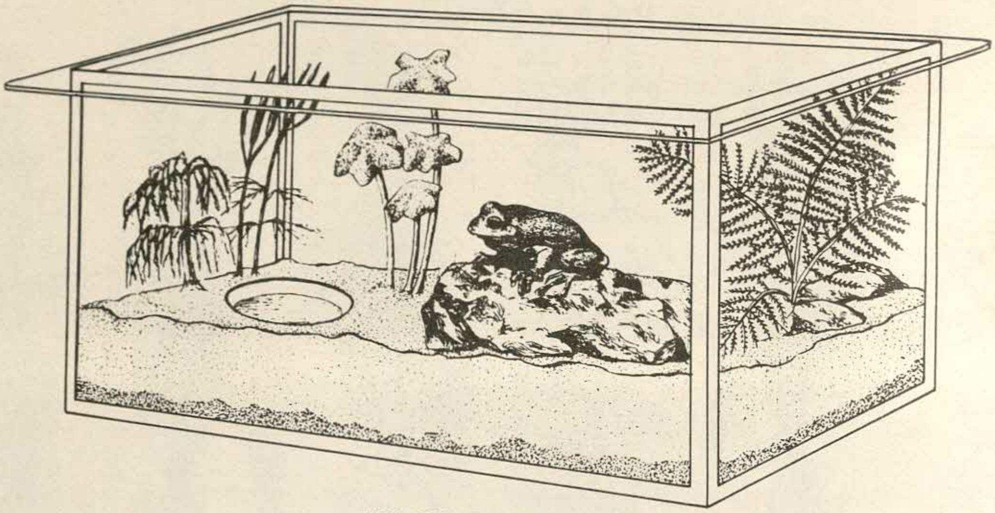
Water poppy Sagittaria Ludwigia Elodea Vallisnaria Cabomba

MAKING A FRESHWATER AQUARIUM

Carefully wash the aquarium and at the bottom place a layer of thoroughly washed sand about two inches deep. Never use sea sand in a freshwater aquarium. Place a sheet of paper on the sand and slowly pour water into the aquarium until the water is about two inches from the top. Remove the paper, root the plants in the sand, and allow the aquarium to stand for two or three days before adding the frog eggs. Keep the aquarium in a warm, well-lighted location, but not in direct sunlight. Three or four snails may be added for interest.



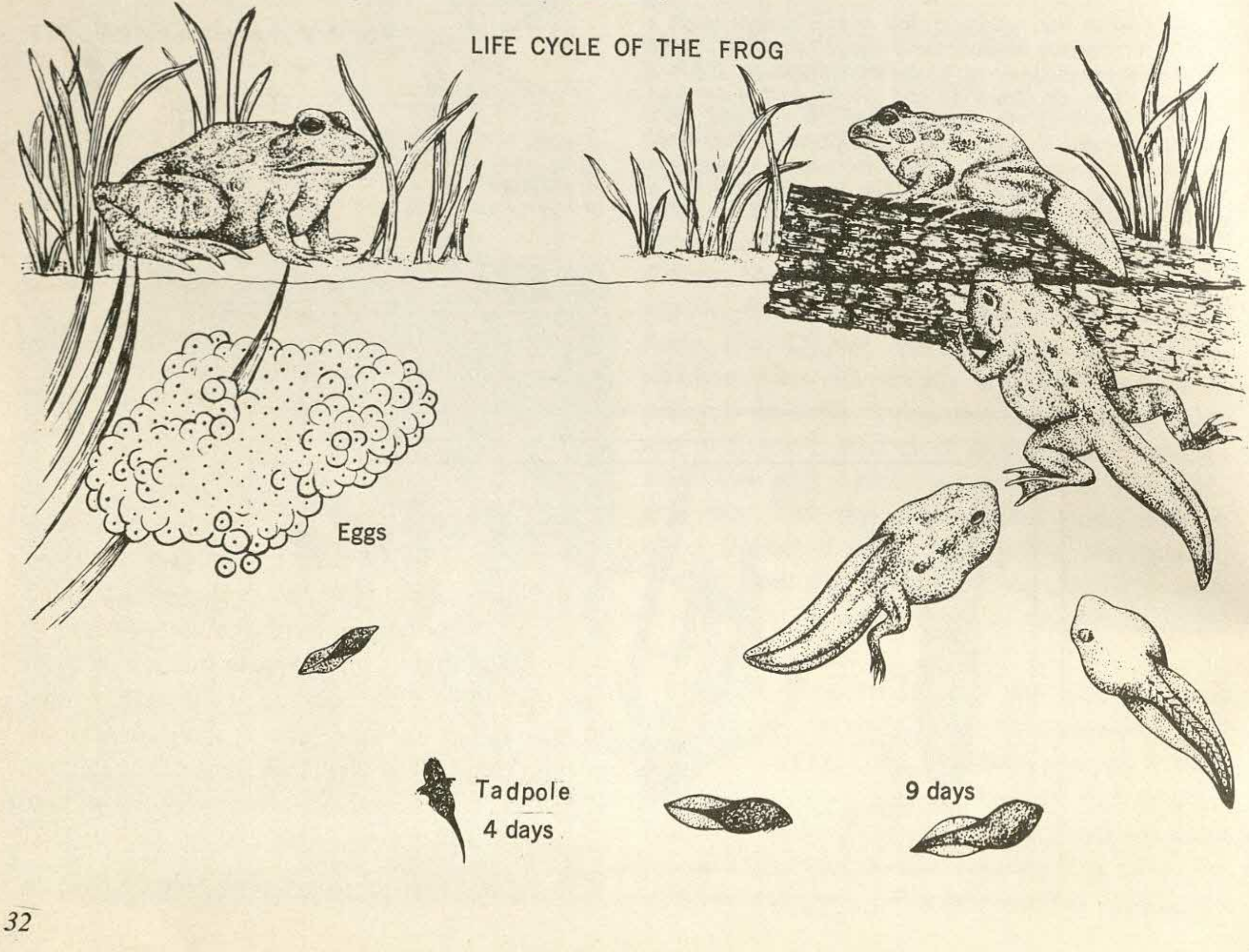


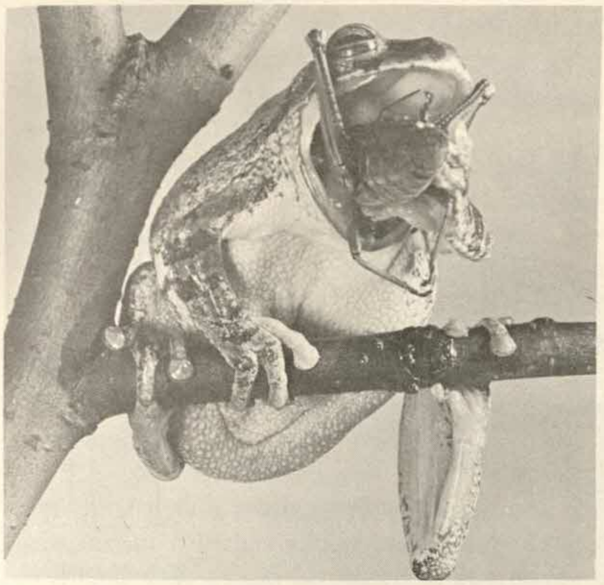


MAKING A TERRARIUM

This terrarium is established in a ten-gallon aquarium, but any large container will do. At the bottom, place a layer of coarse sand or gravel one to two inches deep, covered by a layer of potting soil three to six inches deep. Sink a shallow dish in the soil to provide a pool. Plant an attractive arrangement of mosses, ferns, liverworts, and other small plants, such as ground pine or periwinkle. The terrarium should be watered and the water level kept at about two-thirds the depth of the soil. Too much water will kill the plants. Cover the terrarium with a sheet of glass and then place it in a cool, well-lighted section of the classroom.

LIFE CYCLE OF THE FROG





Adult frogs eat insects which they catch with their sticky tongues. This frog has just caught a grasshopper.

food. Encourage the children to suggest what tadpoles usually eat. *(Algae and other tiny plants in the water.)* Transfer the tadpoles to an aquarium containing green plants.

Ask the class how the feeding habits of frogs differ from those of tadpoles. *(Tadpoles eat tiny aquatic plants; frogs feed on insects and other small animals.)* To demonstrate what frogs eat, let some flies loose in the terrarium and watch the frogs go after them. Explain to the class that the frogs will attack only things that move. They can prove this by putting some dead flies in the tank. *(The frogs will not eat them.)* The children can also try dangling a piece of paper or fabric at the end of a string and jiggling it up and down in the tank. *(The frogs will go after it.)*

In the case of the common leopard frog *(Rana pipiens),* the time it takes for a tadpole to become an adult frog is about three months. If the tadpoles begin to sprout leg buds, place them in combination land–water tanks where they can climb out of the water on to a rock or some earth.

Learnings: (x)Tadpoles hatch from frog eggs. Young frogs are called tadpoles. Tadpoles do not have the same characteristics as adult frogs. They do not look the same, and they do not eat the same foods. (y) The process by which a tadpole develops into an adult frog is called metamorphosis. Metamorphosis occurs in all amphibians.

ACTIVITY 17 (x)

OBSERVING HAMSTERS

Purpose: To acquaint the children with the habits of hamsters

Concepts to be developed: Hamsters are mammals. Like most other mammals, they give birth to live young, and the mother nurses the young.

Materials needed:

2 ready-made hamster cages from a pet shop or scientific supply house, or materials required to build these
2 exercise wheels from pet shop or scientific supply house, or materials required to build these
2 golden hamsters—one male and one female, less than a year old and preferably between 5 and 6 months of age
2 pairs of heavy gardener's gloves
Small cardboard box, about 6 inches square
Newspaper
Food—vegetables, grains, fruit
Water
2 water bottles (purchased from pet shop or scientific supply house)
Milk
Pair of scissors

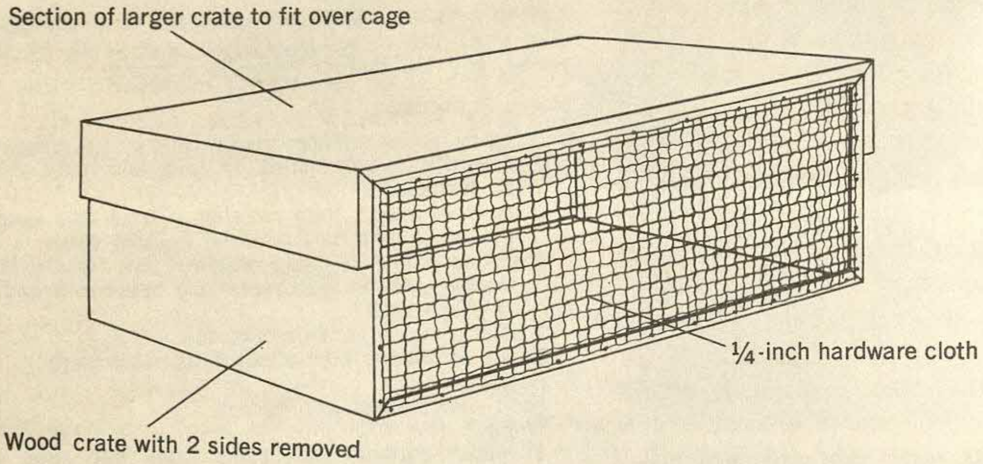
INTRODUCTION: Hamsters are popular pets because they are tame, clean, and inquisitive animals. Tell the children that they are going to watch how hamsters live. They will observe the hamsters' normal habits, such as the kind of food it eats, the amount of water it drinks, and how it behaves. They will also see that hamsters give birth to live young.

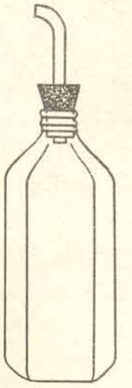
Ask the children what they think hamsters eat. (Vegetables, fruits, grains.) *Emphasize that the hamster, like many other animals, depends on plants for food. Tell the children that hamsters also need water. Ask the children what they think the baby hamsters will need their first days of life.* (Milk from the mother.) *Tell the children that animals that give milk to their young are called mammals. Mammals also give birth to live young.*

Tell the children that hamsters normally live in fields where they get a lot of exercise. Ask the children if they think the hamster will get exercise in a cage. (Probably not enough.) *The hamster* must *have an exercise wheel.*

Each cage should be large enough to house a pair of hamsters. Have the children bed the floor of the cage about 1 inch deep with shredded newspaper (this will absorb liquid wastes). A water bottle fitted with a stopper and a bent glass tube should be placed on top of the cage, so that it rests on it, and the tube is inserted into the cage through the wire screening. The children should be told that the hamsters will die without water. One of the children can be assigned the task of checking the water supply each day.

Homemade hamster cage


Section of larger crate to fit over cage
¼-inch hardware cloth
Wood crate with 2 sides removed



Water bottle

The cage should be cleaned every other day by changing the paper bedding. This prevents odors and protects the health of the hamsters. Have the children discuss the advantages of a clean environment (prevention of disease).

Although hamsters eat continually, they should be fed once a day, preferably late in the afternoon. (Hamsters are most active at night.) They should get a variety of foods, such as vegetables, fruits, grains, nuts, or sunflower seeds and soy beans, food pellets, and dog biscuits. The children should observe how hamsters collect food. *(Hamsters carry food in their cheek pouches and store it in one area of the cage.)* Ask the children what other animals gather food in the same way. *(Squirrels.)* Have the children suggest ways that the hamsters in the wild state get the water that they need although they live in arid areas with very little water. *(They get water from dew and in the food that they eat.)*

Hamsters should be kept in a draft-free part of the room where the temperature ranges between 50° F. and 80° F. At temperatures below 50° F., hamsters go into hibernation (cold slows down their body activities).

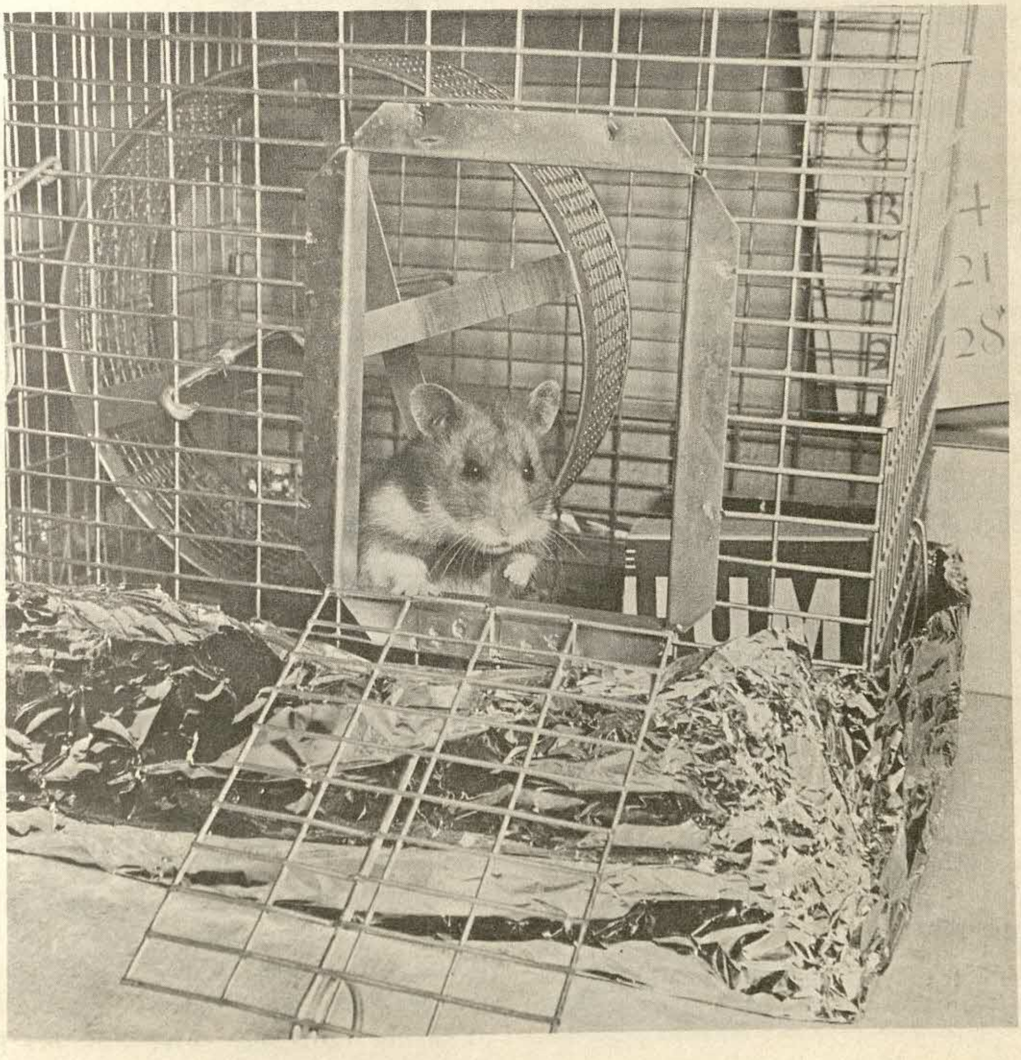
Have the children handle the hamsters so they will get accustomed to humans. The children should wear heavy gardener's gloves while doing this as hamsters occasionally bite. They should examine the hamsters to determine which is the male and which is the female. Viewed from above, the male hamster has a bulge at the base of the tail, while the female's body tapers smoothly to the tail.

Place both hamsters in one of the cages. Within four days the female should be pregnant, since female hamsters go into heat once every four days, and mating is usually immediate once the female goes into heat. At about the thirteenth day of the female's pregnancy, she should be placed in a separate cage. This will prevent the male from eating the litter or exciting the female so that she eats the litter.

The pregnant hamster's cage should be equipped with a nesting box. A small cardboard box, about 6 inches square and thickly bedded, will suffice. It should be placed in one corner of the cage. The box should be a complete enclosure, but an opening large enough for the female to enter and leave the nest should be cut out.

At the sixteenth day of pregnancy (have the children record the time), the female will give birth to the young. The female should be left undisturbed for about four days after she gives birth. Young hamsters are born hairless and with their eyes closed. In a few days a grayish-brown coat of fur, which eventually turns mahogany brown, will appear. The mother will nurse the young for about three weeks. After three weeks, the young can be weaned from the mother and removed from the cage.

Learnings: (x) Hamsters are mammals. They give birth to live young, and they nurse their young. Hamsters bear many young at one time (called a litter). Hamsters eat plant food, and they hoard their food. Hamsters have cheek pouches in which they hold food. Hamsters need water in order to live. Like all animals, hamsters need a suitable environment in order to live.



ACTIVITY 18 (x)

HATCHING CHICKEN EGGS

Purpose: To acquaint the children with reproduction in birds

Concepts to be developed: Birds hatch from eggs. The eggs must be kept in a suitably warm environment in order to hatch.

Materials needed:

Fertilized chicken eggs (about a dozen) obtained from a hatchery, not the grocery store. (Be sure to find out how old the eggs are so that you will be able to tell when they should hatch—about 21 days after being laid.)

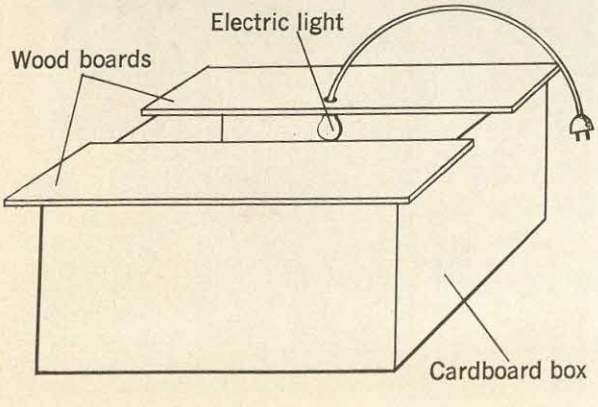
An incubator (preferably a commercial one, but a homemade incubator can be made as shown in the illustration).

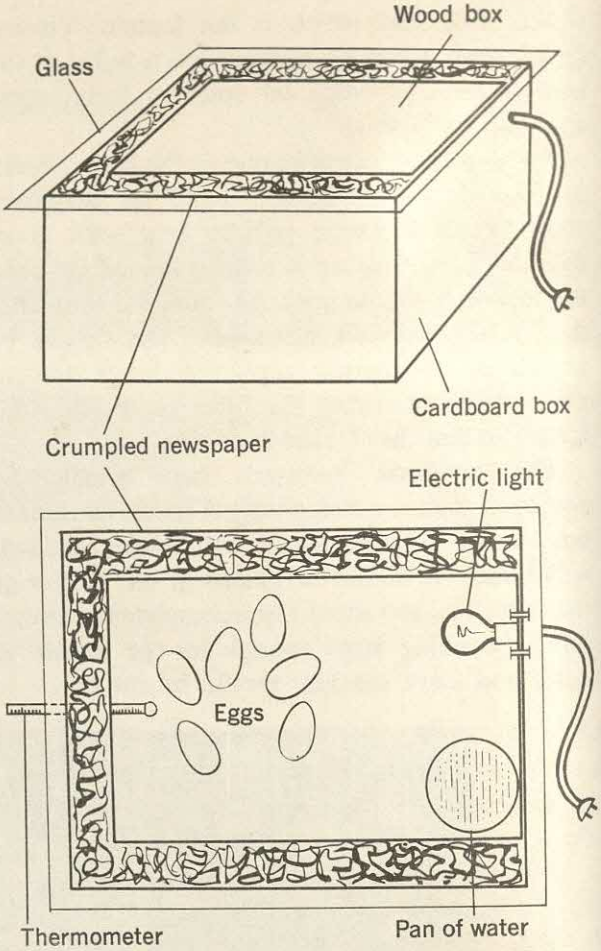
Note: Before starting this experiment, make some arrangements with the hatchery or a local farmer to take the baby chicks shortly after they hatch. Do not allow the children to take them home because the chicks are delicate and will probably die.

INTRODUCTION: Remind the children of the Activity in which they raised frog eggs and tadpoles. Encourage them to recall that the frog eggs were small, round, gelatinous, marked with a dark spot, etc. Also remind them that the tadpoles differed from the adult frogs in having a tail, no legs, a streamlined body, gills, etc. Display the chicken eggs and ask the class how these eggs differ from the frog eggs. (Larger, covered by hard white shell, oval, etc.) *Ask the children if they have seen baby chicks. What did the chicks look like? Did they look like their parents?* (Yes.) *Explain that birds, unlike frogs, do not pass through separate stages of development before they become adults (metamorphosis). Suggest to them that they will be able to see this for themselves in the following Activity.*

Keep the eggs inside the incubator at all times, and do not allow the children to pick them up. (If the eggs are shaken, they will probably not develop.) The temperature inside the incubator must be maintained between 101° F. and 103° F. (If using a homemade incubator, you may have to experiment with several different light bulbs before you find one that maintains the proper temperature.) Tell the class that if the temperature were allowed to drop, the eggs would not hatch. Ask the children if they know how most birds keep their eggs warm. *(By sitting on them —called* brooding.)

HOMEMADE BROODER

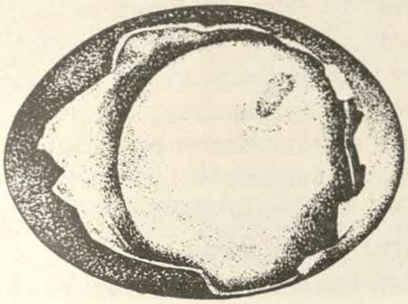




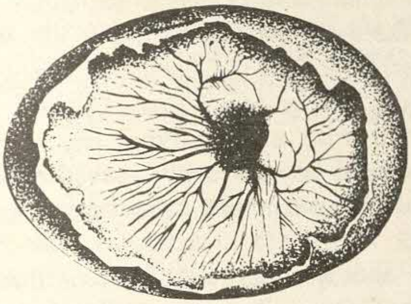
Adjust the humidity of the incubator to about 60 per cent to keep eggs from losing too much moisture. (If you are using a homemade incubator, placing a pan of water in the box will be sufficient.)

Each day the eggs will have to be turned over. (If you mark the sides of the eggs 1 and 2, you should have no trouble remembering which ones have been turned.) Ask the children why the eggs must be turned. *(To keep the developing chick from sticking to the shell on one side of the egg.)* Ask them how this is done in nature. *(The hen turns them over with her feet.)*

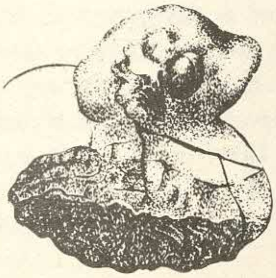
THE EMBRYOLOGY OF A CHICKEN



2 days

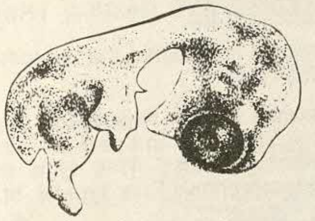


4 days

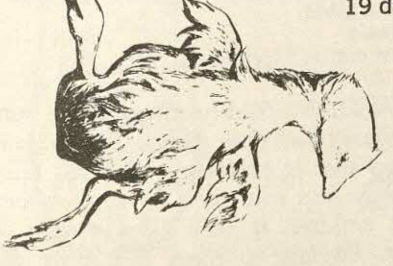


7 days

9 days



19 days



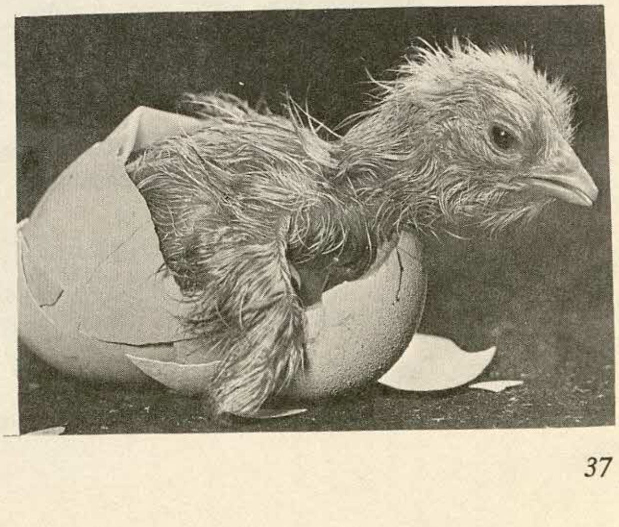
Encourage the class to come to the conclusion that the eggs in the incubator are being kept under conditions similar to those provided in nature (warmth, moisture, turning).

After about twenty days (or sooner if the eggs were not newly laid when purchased), the children will notice a crack or small hole in some of the eggs. Encourage the children to speculate on what is happening. *(The chick is breaking through its shell.)* The children may be able to hear the pecking sounds of the chicks and maybe even some peeping sounds. They may also see the tiny bill of a chick pecking through the shell. (It takes about 8 hours for a baby chick to break completely out of its shell.)

After the newly hatched chicks have dried, remove them from the incubator and place them in a large box that is lined with newspaper and heated by an electric light or a special heater. The temperature of the box should not drop below 95° F. Give the chicks commercial chick feed and water. The following day they may be given to the hatchery or a farmer.

Ask the class to describe the baby chicks. *(They are covered with soft down and are damp.)* Ask the class why they think the chicks are wet. Explain to them that inside the egg a developing chick is suspended in a liquid—the egg white. (All the children have seen a raw egg and know what the liquid is like.) Explain to the children that the liquid protects the developing chick from being injured by jolts and shocks. Also explain that the yolk of the egg contains food for the developing chick. By the time the chick hatches, the yolk is all used up. (Part of the white of the egg is also used for food by the

21 days



chick, but much of it remains.) Now that the children know why the chick is wet, explain to them that it must be put in a warm place to dry out. Ask them how this occurs in nature. *(The mother covers the baby birds with her body.)*

Ask the children if the baby chick resembles adult chickens. *(Yes.)* Ask them if they have ever seen other kinds of baby birds. *(Some of them have seen baby sparrows, cardinals, pigeons, or other birds.)* Ask them if these baby birds resembled the parent birds. *(Yes.)* Tell them that all baby birds look like their parents.

Learnings: (x) Chickens, like all birds, hatch from eggs. The eggs must be kept in a suitable environment in order for chicks to develop. They must be kept warm and prevented from drying out, and they must be turned over once a day. Baby chicks, like other baby birds, resemble their parents. Birds, unlike frogs, care for and protect their eggs and young.

Note: It is likely that some of the eggs will not hatch. If this happens, encourage the class to determine what might have gone wrong. The eggs may have been in a cool part of the incubator, they may have been damaged when they were turned, they may have been injured on the way from the hatchery, etc. Another possible reason for the eggs not hatching is that they may not have been fertilized.

Possibly none of the eggs will hatch. This is probably due to failure to maintain the proper temperature. The incubator may have been too hot or too cold. The eggs may have been allowed to remain at room temperature too long during transit from the hatchery to school. Also, if the eggs were not kept moist, they would not hatch. If the children can determine what went wrong, they may want to try the experiment all over again.

Additional Activities: Some of the children may want to try hatching eggs at room temperature. *(These eggs will not hatch.)*

Some children may want to see if eggs from the grocery store will hatch if they are kept in an incubator. *(These eggs are unfertilized and will not hatch.)*

With older children, you may want to open the eggs at various stages to see what the developing chicks look like. Since the eggs are to be kept under the same conditions as in the above experiment, you may set aside a batch of eggs and keep them in the incubator with the others, conducting both experiments at the same time. Start with about a dozen eggs. After the first day of incubation, remove one of the eggs from the incubator, keeping the top side up (so that the embryo will be floating near the surface of the egg on top of the heavier fluids). Carefully puncture a small hole in the shell with a pair of sharp pointed scissors. Then cut away the top half of the shell. Be careful not to dig the point of the scissors into the center of the egg. The embryo should be easily seen. Let the children examine it with a magnifying lens. The head region should be noticeably curved to the left. In a 40-hour-old chick, the heart should be beating.

Open another egg at the end of three days. Have the children note the differences between the one-day embryo and the three-day embryo. Another egg can be opened at the end of a week. Continue opening an egg about every four days. At some stage you may break open an egg in which no embryo has developed. In that case, break open another egg. However, keep at least two eggs for hatching so as to improve the chances of getting a live baby chick to conclude the Activity.

ACTIVITY 19 (y,z)

BREEDING AND RAISING FRUIT FLIES

Purpose: To observe the reproduction and development of fruit flies

Concepts to be developed: The young of fruit flies hatch from eggs and pass through several stages before becoming adults. This type of development, called "metamorphosis," is typical of many insects.

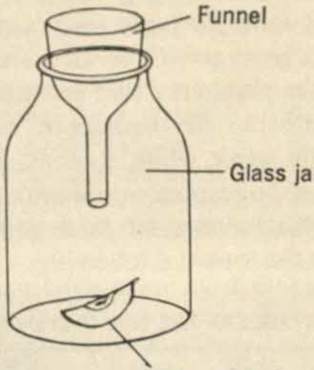
Materials needed:

- One-pint glass jar, with metal screw cap
- Plastic funnel large enough to set on top of the jar
- Very ripe banana or very ripe grapes
- Magnifying glass
- Paper towels
- Absorbent cotton (optional)

INTRODUCTION: Nearly all children have seen the tiny black flies that gather around very ripe fruit or fruit that is beginning to spoil. They probably call these flies fruit flies, or vinegar flies.

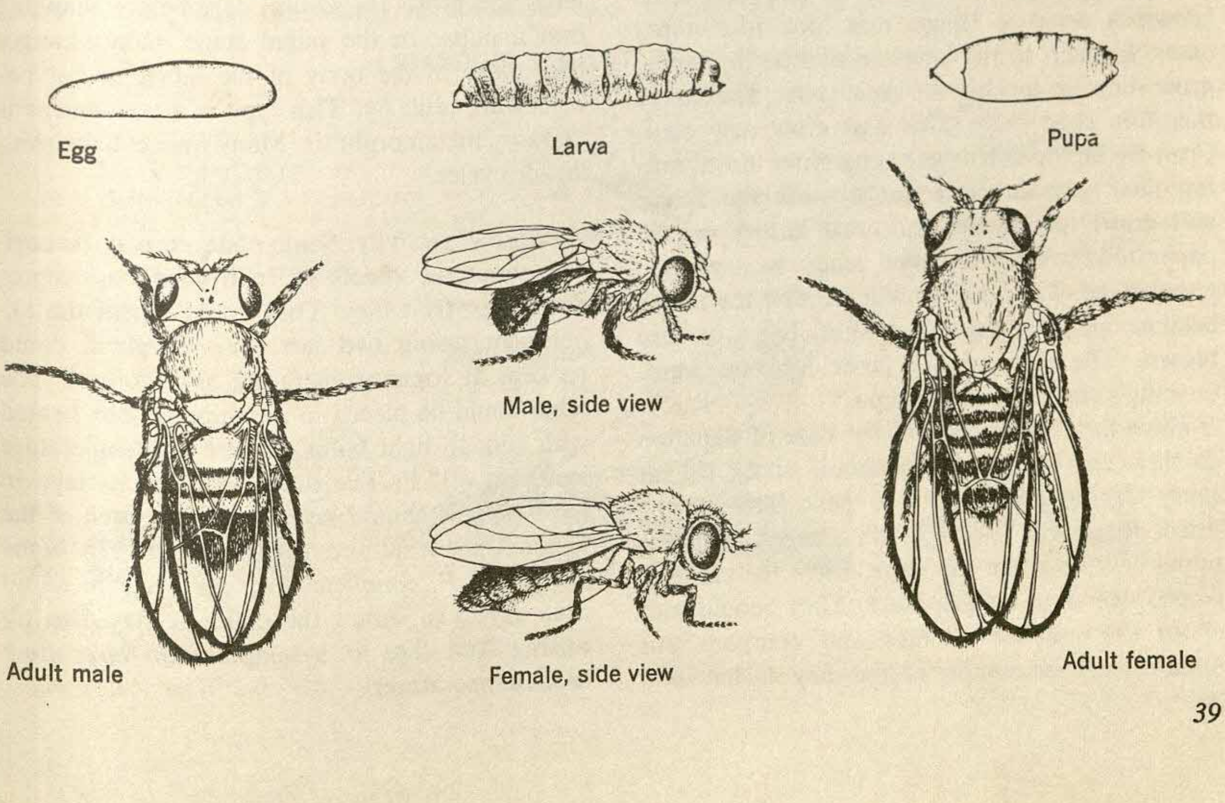
Ask the children if they know where the flies come from. Explain to them that fruit flies, like other insects, lay eggs and that these hatch into *tiny wormlike creatures called larvae, or maggots. Have they ever seen the larvae of other insects? (They may not realize that caterpillars are larvae. Some children may also be familiar with the maggots of houseflies.) How does the larva of a fruit fly become a fly?* (The larva feeds and grows, and after a few days it becomes enclosed in a hard case. This stage of the insect's development is called the pupa. In the pupal stage many changes take place in the body of the larva and it gradually develops into a fly. The fly then comes out of the case.) *Can they think of another insect that develops this way?* (Caterpillars also have a pupal stage before developing into butterflies or moths. In some caterpillars the pupa is enclosed in a cocoon.) *Ask the children to suggest an activity that will enable them to watch all the stages in the life cycle of fruit flies. If they do not have any suggestions, try the following Activity.*

FRUIT FLY TRAP



Have the children place a piece (about half) of a very ripe banana in the bottom of the glass jar. Then place a funnel in the top of the jar. Put the jar in a light warm place, but not in direct sunlight. In a short time, several fruit flies will have gathered inside the jar. The flies hatch from eggs on or in the fruit, or adult flies are attracted by the odor of the fruit. This Activity can be performed at any time of the year, but it is best done in warm weather when the flies are more abundant and conditions are more favorable for the eggs to hatch. After some flies have appeared in the jar, remove the funnel, place a piece of paper towel in the jar, and screw on the cap. Small holes should be punched in the cap, so that the insects can get oxygen. If you wish, the jar can be closed with a loose plug of absorbent cotton instead. The cotton will allow air to pass into the jar. Now have the children count the number of flies in the jar. On the

STAGES IN THE LIFE CYCLE OF THE FRUIT FLY


Egg
Larva
Pupa
Adult male
Male, side view
Female, side view
Adult female

chalkboard, record the date and number of flies. Leave the jar in a warm light place.

At intervals during the day, have the children examine the jar to see if any eggs have been laid. (The eggs will be deposited on or in the fruit. They are very tiny and may be difficult or impossible to see without a magnifying glass. They are small, white, football-shaped, and have two long projections at one end. Scientists do not know the function of these projections. Set up a chart such as the following:

STAGES IN THE LIFE CYCLE OF FRUIT FLY

Form	Date	Description		
		Color	Size	Other
Egg				
Larva				
Pupa				
Fly				

Help the children make drawings of each form when it appears. The drawing can accompany a chart such as the above. In a day or two, the larvae will hatch from the eggs. The larvae live in the fruit and will tunnel around in it. Have the children describe their appearance on the chart. *(The larvae are small, white, and wormlike. Their bodies have eleven sections, called segments.)* Have the children continue to examine the jars each day and watch for new developments. They may notice that the larvae are getting bigger. They may also see some brownish dried-up things that look like empty cases. Explain to the children that as the larvae grow they get too big for their skins. The larvae therefore shed their skins and grow new ones. Fruit fly larvae shed their skins three times during their growth. In about a week the larvae will crawl out of the fruit and gather on the paper towel. They are now ready to begin the pupal stage. The children will see that the larvae become inactive, then their skins begin to turn brown. The skin of the larva becomes hard, forming a case around the pupa.

Have the children record the date of pupation on their chart. Again, they should check the jar every day to watch for the next form of the insect to appear. The fly will emerge from the pupal case in about five days. Have the children record this date on the chart. They should also count the number of flies and compare this number with the number of flies they started with. This number was recorded on the chalkboard at the beginning of the Activity. Since the flies live only about ten days, the original flies will probably be dead by this time.

Encourage the children to answer the following questions about the life cycle of a fruit fly. How many forms does the insect go through? How long does it stay in each form? How long does it take for a fruit fly to develop from an egg at room temperature? *(The complete development should take about two weeks.)* What did the larvae eat? *(They will probably say the fruit. Actually, the larvae eat the yeast and mold that grow on the fruit.)* Did the pupae eat? *(No. The pupa is a resting stage in which the insect is transformed into the adult fly.)*

Note: At the end of the experiment, the flies can be discarded outdoors. However, if a frog is being kept in the classroom in connection with another Activity, the fruit flies can be fed to it. You may also wish to keep the flies for the following Additional Activity. The flies will mate within 12 hours after they emerge from the pupae. The females will lay eggs within a day or two after mating.

Learnings: (y,z) The fruit fly goes through many forms during its life cycle. It develops from an egg. The egg hatches into a larva. The larva feeds and grows for several days before changing into a pupa. In the pupal stage many changes take place in the body of the larva, and it becomes an adult fly. This type of development is know as metamorphosis. Many insects have similar life cycles.

Additional Activity: Some children may be curious about the effects of environment on reproduction in fruit flies. They could repeat the experiment, using two jars, one of which could be kept at room temperature as a control. The other could be placed in a cardboard box heated with enough light bulbs to raise the temperature to about 80° F. The duration of each stage in the life cycle should be recorded for each of the jars, and the results compared. *(The insects in the jar at 80° F. complete their life cycle in about nine days.)* In winter the children may also try raising fruit flies at a temperature lower than room temperature.

ACTIVITY 20 (x, y)

OBSERVING AN ANT COLONY

Purpose: To learn how the members of an ant colony live

Concepts to be developed: Ants are social insects; they form colonies. Each member of the colony performs a specific task that helps the colony survive.

Materials needed:

Ants
Food (grains, vegetables, and scraps from the children's lunches)
Ant home
Black construction paper
Red cellophane
Dirt
Collecting bottle
Sheets of cardboard

INTRODUCTION: Many children do not realize that one of the most familiar insects—the ant—is also one of the most unusual and fascinating. Ants and a few other insects, including some kinds of bees and termites, are social animals. They live in large colonies, whose members are specialized to perform certain tasks. These specializations are for the benefit of the colony as a whole, not the individual, although the welfare of the individual depends upon the welfare of the colony. This unusual adaptation provides us with one of the most fascinating studies of how cooperation among social insects helps the species survive.

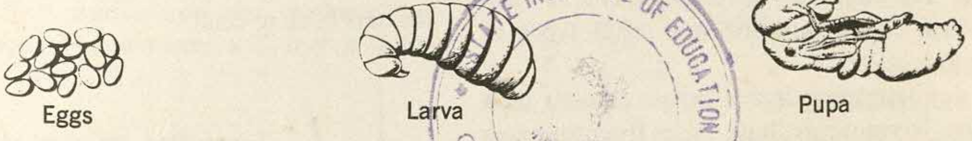
Tell the children that they are going to build an ant home. To heighten their interest in this project, they should learn something about the life cycle of the ant and of the typical colony. Encourage them to supplement the following basic outline with library research. Many fascinating specializations of various ant species, such as herding aphids, cultivating fungi for food, and capturing slaves, will be found.

When an ant colony reaches a certain size, a generation of fertile females and males is produced. These individuals are winged. On a sunny day they crawl out of the nest and fly up into the air, where they mate. After they have mated, both males and females return to the ground. Since the males serve no function other than fertilization, they die. The females break off their wings and then begin to search for a home. Those that have landed near the nest may be accepted back into it. More often, however, they have been borne by their wings and air currents far from the original nest. Each female must therefore begin her own independent colony.

When the ant finds suitable soil, she burrows into it and forms a chamber at the end of the tunnel, which she seals shut. She then lays several eggs, gathers them into a bunch, and tends them by licking them clean and keeping them warm and moist. While the eggs are incubating, the muscles used to power her wings are being absorbed into her body and converted into a liquid food for the white legless larvae that will hatch from the eggs. The children may have seen these larvae; they are sometimes sold as fish and turtle food in pet stores.

The larvae grow, shedding their skins several times as they become larger. The first generation of larvae do not grow as large as succeeding generations because they are not as well nourished. After they have shed their skins several times, the larvae form puparia in which they pupate, or change into adult form. The small adults that emerge from the puparia are workers, sterile females whose sole function is to provide food for the queen, enlarge the nest, and care for future generations.

STAGES IN THE LIFE CYCLE OF AN ANT



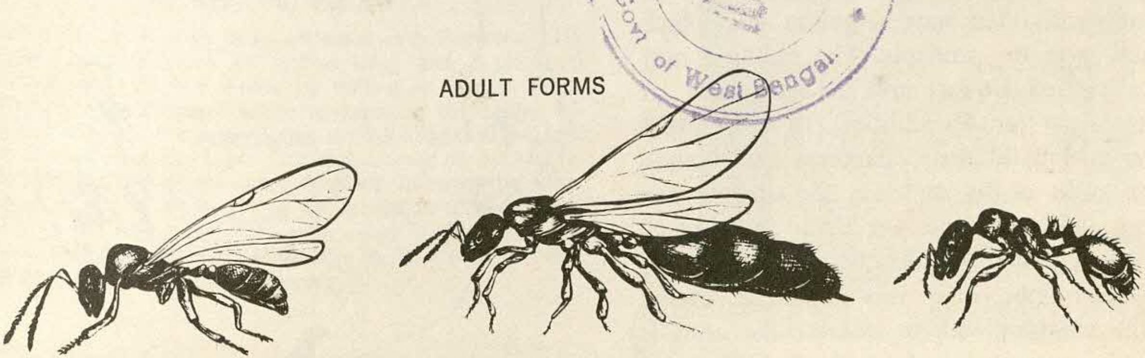
Eggs

Larva

Pupa

INSTITUTE OF EDUCATION Govt. of West Bengal.

ADULT FORMS



Male

Queen

Worker

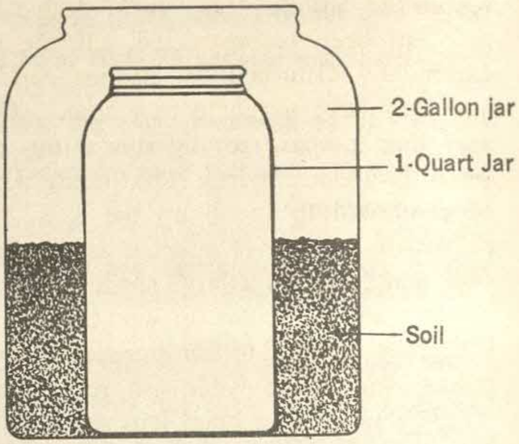
The queen then lays more eggs, while the workers tunnel out and search for food and dig more tunnels and chambers for the nest. As mentioned previously, this generation will have larger individuals because the workers feed the larvae better than the queen fed them. Thus the colony becomes established. The queen will lay more eggs, which will develop into other sterile females who will tend the colony and provide for the survival of the species. Eventually, perhaps after several years, the colony will reach a size and stability that permits the emergence of another generation of fertile female and male ants that will take wing and spread the species to other places.

The children can find an anthill close to school and observe how the ants live in their natural habitat. One child can disturb the anthill so that the activities of the insects can be seen. Worker ants will carry the eggs and pupae to safety and scurry for protection. Suggest that the children note the site of this ant nest and come back to it later. Ask them to keep in mind the confused condition of the colony, in order to compare its state when the class returns.

Ask the children how they might study ant life in the classroom. They will guess that they need a specialized terrarium called an ant home. The children may make either of the two ant farms suggested below. No matter which they choose, they must consider several factors. First, the major part of a colony lives below ground; therefore, the children will need a deep container. Second, ants tend to shy away from light; therefore, the children will have to devise a method of blocking out light. Third, ants need food and moisture. The children can experiment in class to find how much moisture and what types of food the ants prefer.

The simplest kind of ant home consists of a large jar. Restaurants buy their food in mass quantities and often have 2-gallon jars which they may give to students. The children may insert a capped 1-quart milk or fruit juice jar into the larger jar. In addition, to help insure that the ants build their chambers and tunnels along the sides of the jar where the students can see them, have the children wrap some black construction paper around the outside of the jar to block light. Keep this paper on, except when the children wish to observe the ants. It is not necessary to cap the large jar. The ants will not escape if the jar is set in water.

SIMPLE ANT HOME

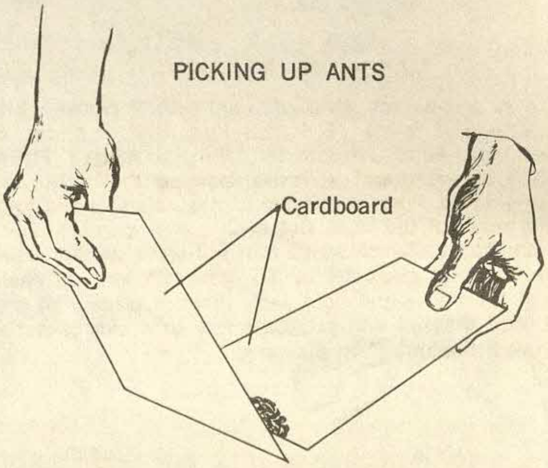


The second type of ant home is more difficult to build, but more rewarding because there is increased surface for observation. This ant home is described in the illustration.

Have the children tape a piece of red cellophane over one sheet of glass. They should then tape black construction paper over both sheets. When the children lift the black paper for observations, have them compare the reactions of the ants on the clear side with the reactions of the ants on the side covered with red cellophane. *(Red cellophane will block out much of the light, so the ants will not move away as quickly as on the clear side.)* The completed ant home should be set in a shallow pan of water.

The children may now fill either their jar or framed ant home ½ full with sandy soil. They should also fill another jar with a cap about ¼ full. This capped jar will be used to transport the ants back to class.

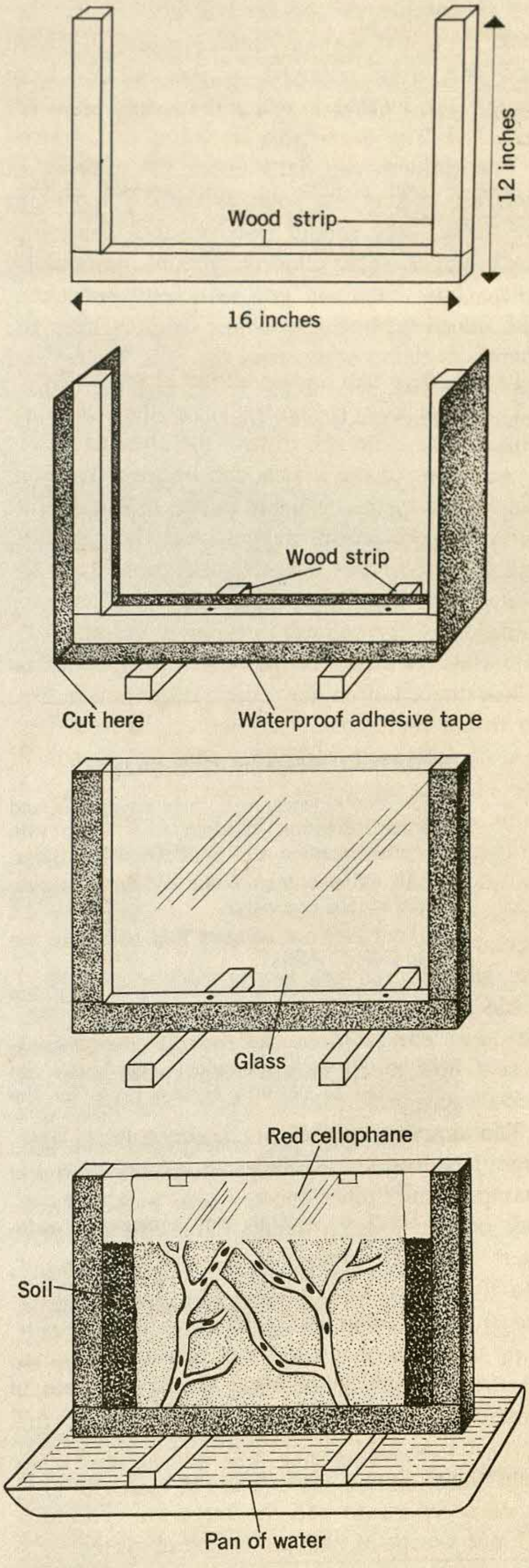
PICKING UP ANTS



The children should revisit the site where they found the anthill. Have them notice how the nest has been reconstructed. (If the nest was continually disturbed by curious children, the ants may have sought a new home.) One child may then prepare to dig down into the nest, while the other children stand ready with pieces of cardboard to scoop up the ants. Have the child with the shovel insert it as deeply as possible and bring up a large spadeful of dirt. The children should scoop up workers, larvae (legless grubs resembling semitransparent white rice grains), and pupae (yellowish, resembling grains of wheat). Using a hand lens the children may try to find eggs. Stress that a queen must be found, if the colony is to continue. Have the children look for a queen from 6 to 8 inches below the surface of the ground. A queen may be distinguished by her larger size. Her abdomen may be quite swollen by eggs and its plates separated. The children should gently transfer their ants into the collecting jar. Do not throw or pack dirt in, as the pressure may kill the ants. When the children have found from fifty to one hundred ants and a queen, they are ready to return to class.

Carefully transfer the ants and dirt from the nest into the ant home, which should be set in indirect sunlight. The children should keep the nest moist by sprinkling the top with water every other day. They may put different kinds of food, including vegetables, cornflakes, pieces of meat, scraps from their lunches, etc., on top of the soil to see which kinds the ants prefer. Have the children notice how the workers approach the food. The workers will feel it with

FRAME ANT HOME



MAKING AN ANT HOME

Cut a ¾ by ¾ inch strip of wood into 2 pieces 11¼ inches long, 1 piece 16 inches long, and 2 pieces 6 inches long. Form a frame by nailing as shown. Place a piece of waterproof adhesive tape on the table, adhesive side up. Place the frame on the adhesive and fold up the sides of the tape. Cut each corner on each side. Nail on the two 6-inch strips that will serve as the base. Set a sheet of glass 12 by 16 inches in size on each side of the frame and hold each sheet in place with the tape. Add the soil and set the frame in a pan of water to prevent the ants from escaping.

their antennae, which they use to "smell." If it is acceptable, the worker will hoist it over her back, even if it is many times her size. Rejected food should be removed by the children from the surface so that it will not rot and spoil the nest.

The children can daily check the progress of their ant colony. As soon as their observations are made, they should re-cover the home with black paper. The children should particularly notice how members of the colony cooperate. The queen lays eggs. Various workers keep the chambers clean; others tend the eggs, larvae, and pupae; others go out for food; and still others defend the nest. All work for the well-being of the colony.

The children may keep a record of the ants' progress in tunnel building by laying a sheet of clear plastic over the glass and tracing the tunnels and chambers. Each day's progress could be traced in a different colored grease pencil. For example, tunnels observed on Monday could be marked in green, and any new tunnels that appear by Tuesday could be marked in blue. This plastic sheet may be pinned on white paper on the bulletin board for continued comparison and reference.

Learnings: (x) Ants are social insects; they live in colonies. Each member of the colony performs a specific task that helps the colony survive.

Additional Activities: If the children have done library research, they will be able to design several additional activities on their own. For example, they might try removing a worker for a few days and then returning her to the colony. Observe how the other workers brush their antennae over her. When she is recognized, she will be readmitted to the colony. Try putting an ant from a different colony into the colony and see what happens to her. Her entry will be challenged, and she may be captured or killed.

IMPORTANT IDEAS IN THIS CHAPTER

For the kindergarten, primary-grade, and intermediate-grade children, the ideas with the most meaning and application are these:

- All animals require air and an adequate supply of food and water.
- Fruit flies are animals that belong to the group called insects.
- Ants are animals that belong to the group called insects.
- Ants are social insects that live in colonies. In each ant colony, individuals are specialized to perform certain tasks for the colony.
- Most ants live underground and build tunnels and chambers in which to live and raise their young.
- Frogs are animals with backbones (vertebrates).
- Frogs are amphibians and spend part of their life cycle in water and part on land.
- The frog lays eggs in water.
- The eggs hatch into tadpoles, which develop into adult frogs. The tadpole lives in water, eats plants, and breathes by means of gills.
- The adult frog lives on land near water, eats insects, and breathes by means of lungs.
- Birds are animals with backbones (vertebrates).
- Some birds eat seeds; others eat insects and meat. Some birds, such as the humming bird, require special food. The humming bird eats the nectar of flowers.
- Chickens are animals that belong to the group called birds. They are covered with feathers and reproduce by laying eggs.
- Bird's eggs must be kept warm during incubation.
- The baby chick resembles the parent from the day it is hatched.
- Hamsters are animals that belong to the group called mammals.
- Hamsters require air, food, and water. Hamsters eat seeds and vegetables.
- Hamsters give birth to live young. The young resemble the parent.

In addition to these ideas, in the intermediate and upper grades the children should be led to develop concepts that are more complex.

- Insects go through egg, larva, pupa, and adult stages during their life cycle. The process by which the larva becomes an adult is called metamorphosis.
- The change of a tadpole into a frog is called metamorphosis. Metamorphosis occurs in all amphibians.

4

INVESTIGATING ADAPTATIONS OF LIVING THINGS

"What happens to animals like frogs and toads when winter comes?"

"Why don't we see as many birds in the winter as we do in the summer?"

"Why do some leaves turn yellow, red, and brown in the fall?"

Perhaps your children have asked you questions like these. If the children live near a woodland or forested area, they can observe animal behavior during different seasons of the year. Children who live in a city have parks and zoos where they can visit and observe animals.

Living things change. Some of these changes are readily observable, and others take place very slowly over several generations of plants or animals. Children can observe many of these changes: for example, changes of seasons, coloration of leaves, different stages in the life cycle of a plant or animal, and appearances of animals.

Plants respond to seasons in colorful and interesting ways. The children can readily observe these alterations and discuss why they occur. Animals react to seasonal changes in varying ways also. Some animals hibernate; others migrate to different surroundings for a period of time during the year. Because of environmental modifications and other factors, changes will continue to occur. Living things react to their environment in a wide variety of ways.

HOW DO ANIMALS RESPOND TO THEIR ENVIRONMENT?

ACTIVITY 21 (x,y,z)

OBSERVING MIGRATING BIRDS

Purpose: To show that migration is one form of adaptation

Concept to be developed: Some birds migrate when seasons change.

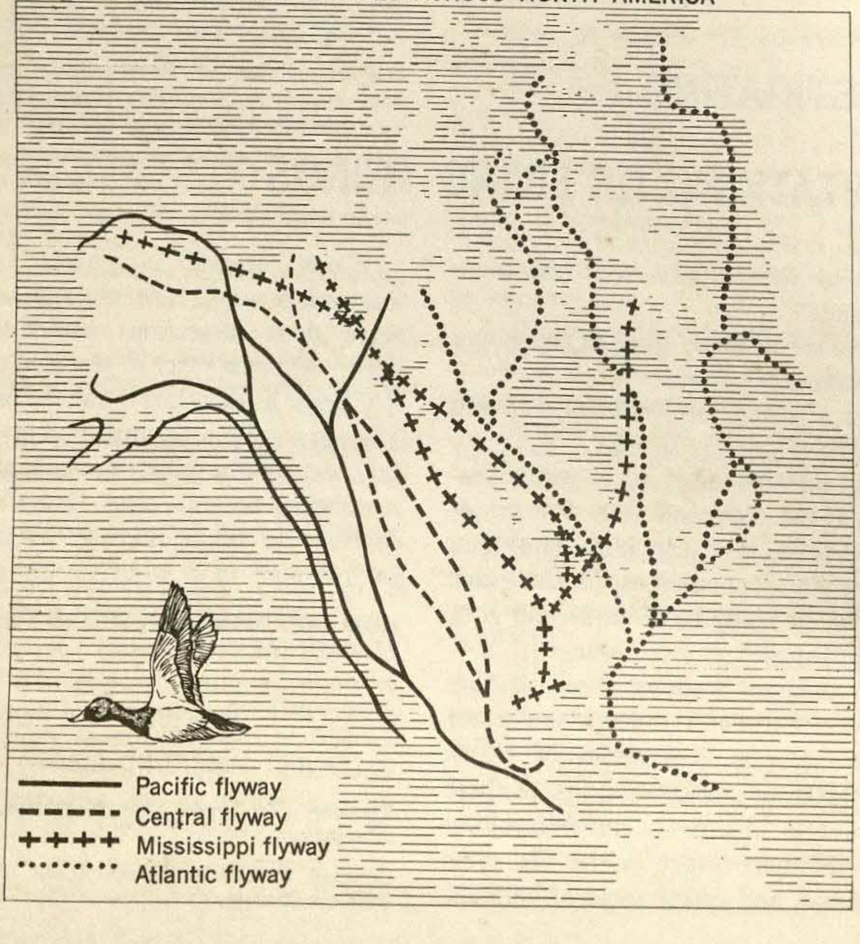
INTRODUCTION: This concept cannot be developed by using experimental methods in the classroom. However, the Activities suggested can be carried out by the children during the school year and will give them some understanding of how birds and other animals migrate as an adaptation for survival. Birds take certain paths in their migrations to warmer climates. These paths are called flyways. *No one knows why birds migrate, but scientists are working to determine the reasons. To follow the routes of the migration of birds, scientists mark birds (placing small bands on their legs or wings) and ask people to report where these birds have been trapped or shot. This information is sent to a central location where the observations are recorded. In this way, the paths of the birds can be studied and maps made of such routes. There are several major paths which have been detected in this manner. One of the largest flyways follows the Mississippi River Valley, across the Gulf of Mexico, and on to South America.*

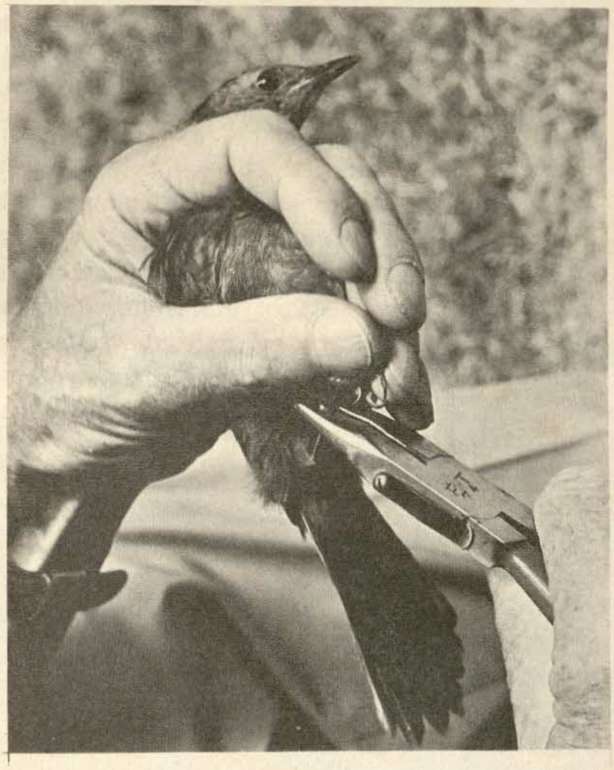
The bird population of a given area changes a great deal during the course of a school year.

Have the children keep a detailed record of birds seen in the vicinity of the school building during each month of the year. From these entries the boys and girls can determine which birds migrate and which ones stay in the area all winter. A bulletin board in the room can be utilized for this year-round study. Children can also collect pictures of the birds they see during different months of the year and place them on a bulletin board. Which birds are the first to return in the spring? Several of the children might like to make special reports on specific birds. In these ways they could learn more of the migration habits of birds.

Additional Activities: In addition to maintaining a local record, the children might read and do some research on major flyway routes in the world and plot these routes on an outline map of a specific continent or the world. The winter and summer homes of the birds can be located on the maps. The children can measure the distances between the summer and winter homes and determine the distances that birds fly during a migration. The migration routes can be marked on a globe, with colored yarn marking the paths between the summer and winter homes.

MIGRATION ROUTES ACROSS NORTH AMERICA





Banding a bird as part of the study of migration.

Arrangements can be made to have a representative of the Audubon Society or the local conservation officer show how birds are banded and discuss ways in which the migration habits of birds are studied. These representatives can also provide pictures to help the children in the identification of birds and give them suggestions for recognizing local birds. The children can prepare a bulletin board showing the common birds in the vicinity of their homes and the school. This helps in identification of birds.

Do you have any bird sanctuaries in the vicinity of your city? (Many birds stop at sanctuaries or shelters when they are migrating. Ducks and geese often cover an entire lake. These refuges are necessary because the natural homes of birds are being destroyed by the rapid expansion of populated areas. It is against the law for hunters to shoot birds when they are in such a sanctuary.) If there is no sanctuary near your city, you and your class might build a bird sanctuary. Have the children contact the local Audubon Society or the local conservation officer for suggestions and assistance. (Many cities and towns have been declared bird sanctuaries in and of themselves to protect birds within their environs.)

By reading, children can discover migration habits of animals as well as birds. Have them look up information on the salmon, seal, bat, lemming, elk, eel, and the monarch butterfly. These are some of the animals whose migratory habits have been studied. The children might prepare a bulletin board display, using their own illustrations and stories they have written.

Learning: (x) Birds and other animals migrate as an adaptation for survival.

ACTIVITY 22 (x,y,z)

STUDYING ANIMALS THAT HIBERNATE

Purpose: To show that hibernation is one form of adaptation

Concept to be developed: Some animals hibernate during the winter months.

INTRODUCTION: This activity is observational rather than experimental.

Some animals hibernate during the winter months. The animals burrow deep into the ground, often below ground-frost level. While an animal is in hibernation, the life processes are slowed down. Some animals hibernate for as long as five months. Frogs, which hibernate in mud at the bottom of ponds, do not eat during this period of rest. They live on the stored fat from the body. Snakes often hibernate in a hole with several other snakes of the same species. Turtles hibernate in the bottoms of ponds or along the edge of a stream bottom, where they burrow down into the mud and remain until the spring.

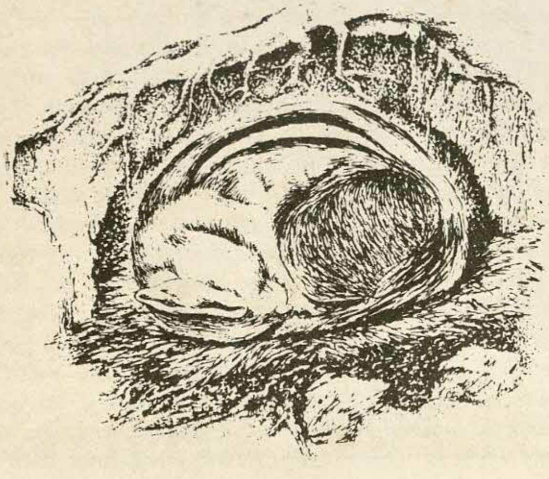
Some mammals hibernate during the coldest part of the year. Other mammals do not hibernate, but are inactive and asleep most of the time during the colder portions of the winter. A warm spell will bring them out of their nests. Field mice, for example, are inactive during the colder parts of the winter. Squirrels, too, sleep when the weather is cold.

Since local conditions vary considerably, as far as the species of animal life are concerned, the children might want to make a careful study of the types of animals existing in their community. The local game warden, or similar person, can be invited by the children into the classroom to discuss local animal life. Many of these men are very willing to lead the children on field trips to nearby areas to help answer their questions. With this background information, the children can then observe the local environment in an effort to determine the hibernation habits of various animals. They should keep a detailed written record, including the date when a particular animal is seen in the community, the date when the animal seems to have disappeared, and the time when it is seen again. Reading will help them in

A woodchuck emerges into the warm spring air after hibernating in his hole all during the winter months.

This meadow jumping mouse was dug up during the winter and is still in a state of hibernation.

During the winter when the air is cold and food is scarce chipmunks hibernate in burrows in the ground.



drawing any conclusions from their observations. From a study of their observations the children will discover that animals adapt to seasonal changes in a variety of ways, such as migration, hibernation, and growth of extra hair.

The children can make a "spot" map or an illustrated picture map of an area near their school where animals are seen. When individual animals are seen, some of the children might like to collect pictures and prepare stories for bulletin board use. You can suggest to the children that each of them can select a different animal and prepare a report about it that includes the approximate time of hibernation, place of hibernation, its regular home, and other information about how it lives. To illustrate the reports, the children can obtain pictures or make their own drawings. After all the reports are completed, the children can assemble them into a class book, with a title such as *Animals That Hibernate.*

Learning: (x) Some animals hibernate during the winter as an adaptation to seasonal change.

ACTIVITY 23 (x,y,z)

OBSERVING COLORS IN ANIMALS

Purpose: To help the students discover one of the ways that animals are protected from their enemies

Concept to be developed: Animals are protected by their coloration.

Materials needed:

100 toothpicks painted different colors
100 toothpicks painted green

INTRODUCTION: The toad looks very much like a clod of dirt, and the young fawn blends with its surroundings and is most difficult to see. The ptarmigan becomes white when the snow begins to fall in the mountains. As spring approaches, the ptarmigan's color slowly changes to brown, blending into the environment. Many snakes also take on the appearance of their surroundings.

The children can locate many other examples of protective coloration by observing the animals in the community and by reading reference books.

The following Activity will help children to discover the role of color in camouflaging animals. Paint 100 toothpicks green and mix them with 100 toothpicks painted different colors. Throw the toothpicks in a grassy area around the school. A group of children can then pick up

COLOR	NUMBER FOUND					
	FIRST MINUTE	SECOND MINUTE	THIRD MINUTE	FOURTH MINUTE	FIFTH MINUTE	TOTAL
NATURAL						
YELLOW						
ORANGE						
RED						
GREEN						
BLUE						
PURPLE						
BLACK						
BROWN						

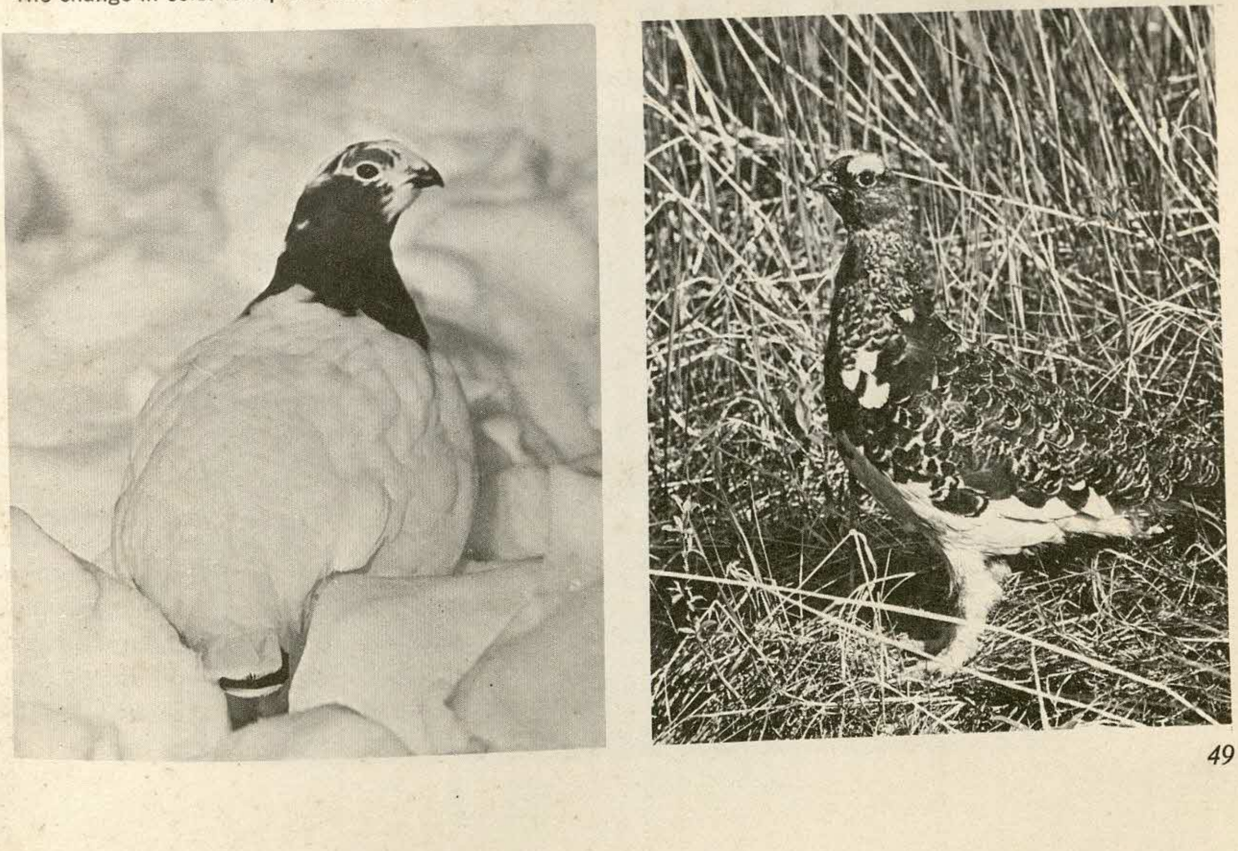
STATE INSTITUTE OF EDUCATION
Govt. of West Bengal.

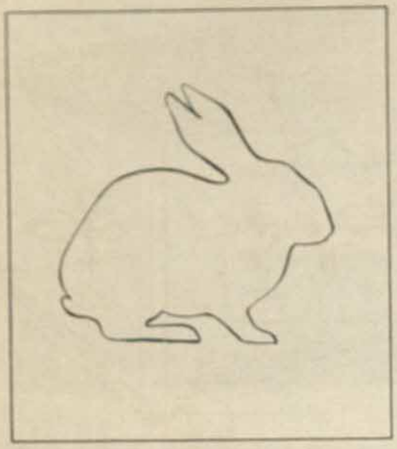
toothpicks while another child keeps track of the time. At intervals of 1 minute, the hunters stop to count the number of each color toothpick that has been found. One child can keep a record. After 5 minutes, time is called, and the students should return to the classroom to plot a graph showing the number of each color toothpick found. *(The green toothpicks are usually the hardest to find because they blend into the background.)* The children should be able to determine the role of color in animal protection from the data gathered and plotted on the graph.

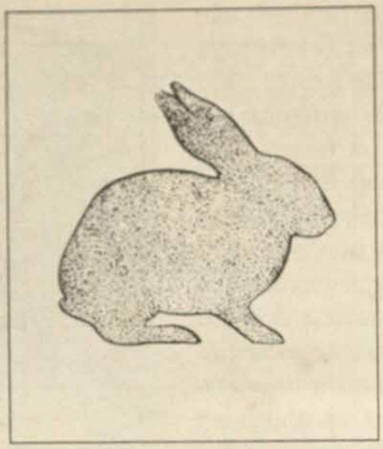
Learning: (x) Animal coloration is one of the ways that animals are protected from their enemies.

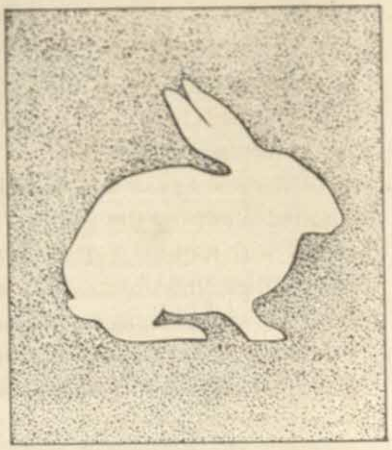
Additional Activity: The following Activity may be expanded into a mural for display in the classroom or in the hall. The children may make different animals, such as a frog, a rabbit, a fish, and a lizard, from construction paper. They should then pin the paper animals on papers of various colors to simulate colors found in nature. White paper represents the white of

The willow ptarmigan changes color during the year to blend with its environment both in winter and in summer. The change in color is a protective adaptation that helps the bird survive by concealing it from its enemies.









the snow; pale green, a young plant stem; blue, the sky or water, etc. By placing a white rabbit cutout on white paper and a white rabbit cutout on dark green paper, the children might also emphasize the role of color as a protective adaptation. If these were real rabbits in natural environments, which would stand a better chance of survival? Why?

ACTIVITY 24 (y,z)

OBSERVING COLOR CHANGES IN THE ANOLE (AMERICAN CHAMELEON)

Purpose: To determine the effects of light and temperature on the coloration of the anole

Concepts to be developed: Animals may have the same coloration as their environments. This protective adaptation helps conceal them from predators. The green anole changes color in response to light and temperature.

Materials needed:

2 green anoles (American chameleons): a male and a female
Wooden box (apple crate)
Fine-mesh hardware cloth
25-watt bulb
Branches with leaves or potted plant
Rock
Sandy soil
Brown and green cloths
Plastic bag
Paper toweling

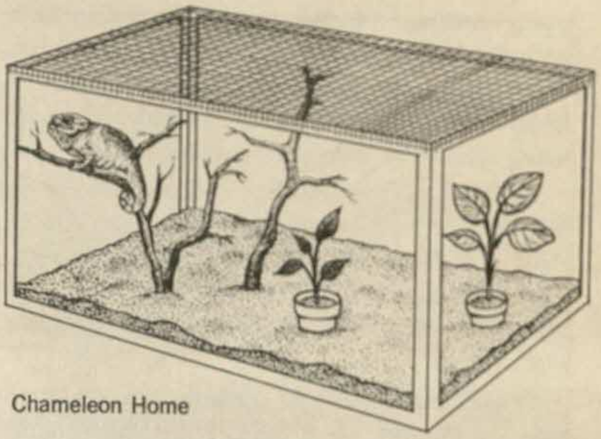
INTRODUCTION: Have the children bring in pictures of various animals in their natural environments. Encourage them to find pictures of desert dwellers, snow dwellers, tree dwellers, and water dwellers. Ask the children how the color of these animals protects them against their natural predators. The children may know that a young fawn cannot run fast and that its spotted coat helps camouflage it as it lies under bushes. Ask them why they think mature deer do not have spotted coats. Discuss why birds, fishes, and frogs are usually one color on top and another on the bottom. If the children are puzzled, ask them to consider where the predators of these animals may be lurking. Lead them to suggest that some predators may be below them and others above. A light-breasted animal, when viewed against the sky, is difficult to distinguish. When viewed from above, the dark colored backs help camouflage them against the earth or water. Consider the fish as an example, and have the children relate its color to its environment. You might tell the children that the protective coloration of fish has been borrowed by man. Have the children guess why life rafts are usually blue on the bottom and bright yellow on top. (The blue conceals the raft and its occupants from sharks and other dangerous sea dwellers. The yellow attracts search planes.)

In addition to permanent coloration, many animals change color as the environment changes. The ptarmigan, a fowl-like bird, changes from brown in the summer, to gray in the autumn, to white in winter. The snowshoe rabbit changes from grayish brown to white in the winter. The children should relate these changes to seasonal changes in the vegetation and ground cover. Inform them that they are going to observe how the green anole, a lizard common in the southeastern United States, changes in response to factors in its environment.

Obtain a male and a female American chameleon, properly called the green anole *(Anolis carolinensis)*, from a pet store or a scientific supply house. (If you purchase your anoles from a pet store, buy ones that are fat and active.) The green anole, which will probably be brown when you get it, is often sold with the claim that it will take on the color of whatever it is placed on. Tell the children that one of the things they are going to do is see whether or not this is true.

The anoles, like other animals brought into the classroom, should be kept as comfortable as possible in an environment similar to their natural one. To build a suitable environment, the children should make a terrarium. Inside place a rock and a few freshly cut branches or a potted plant for the lizards to crawl upon. The anoles will require living food, including mealworms, flies, and moths. Flies may be lured inside the terrarium by hanging a bit of meat or fruit on a string. Anoles may also be trained to eat hamburger by offering them mealworms on tweezers. Soon they will learn to snap at anything on tweezers. Every other day sprinkle water on the plant. The anoles will drink the drops on the leaves. The terrarium should be placed where it will receive a few hours of sunlight each day, yet about 80° F. To provide sufficient heat during the winter, place a 25-watt bulb in one corner of the terrarium, again making sure that there are some shady areas.

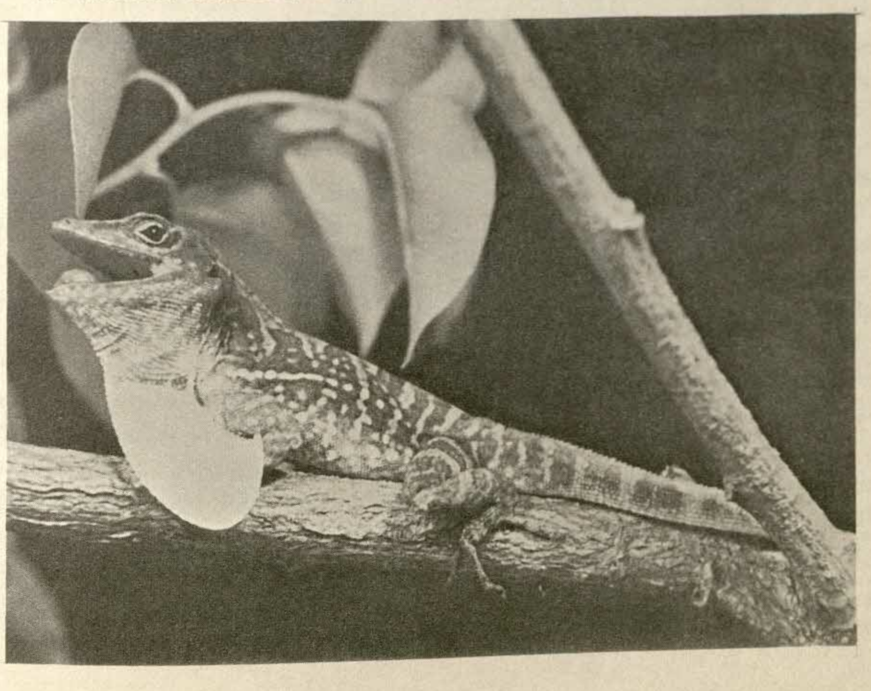
When the children have placed the lizards in their new home, have them observe some of the animals' characteristics. Discuss how their long toes help the anoles run on branches and how their tails help them keep their balance. Observe how they eat. Have the children compare these lizards with other reptiles, pointing out how they are adapted to suit their environment—trees.



Chameleon Home

As the initial experiment, the children may test whether or not an anole will assume the color of its environment. They may do this by placing the lizards on green and brown cloths. If your anoles are not used to being handled, they may become excited and change color or stiffen. If this occurs, the children should discuss how the color change or stiffening might protect the animals. Have them recall that most creatures prefer to catch and eat living things and that stiffening makes the anoles appear dead. On the cloths the lizards will probably change shade, but not color. Inform the children that the anole, like many other lizards, changes color with its emotional state or in response to temperature or light. When a male anole is

The American chameleon, or green anole, can easily be kept in the classroom.



trying to attract a female or to bluff another male away from his territory, he expands his dewlap, which exposes the scarlet skin between the scales. If he wins a fight with another male, he turns green; and if he loses, he turns brown.

To observe how the anole changes color in response to temperature and light, the children may vary these factors in the following ways. The experiments should be brief, however, and the anoles should be returned to the favorable environment described above.

If it is about 50° F. outdoors, the children may temporarily place the cage on the window ledge. The anoles should turn brown in 3 to 10 minutes. Bring them back indoors to where the temperature is over 70° F. If the light is bright, the anoles will remain brown. But if the anoles are put in a dark place, they will turn green. Since the color changes are rather slow, the children will have plenty of time to turn on the light in a dark room and observe any color changes. If you can raise the temperature to about 105° F., taking care to keep the environment humid, the anoles will turn a pale grayish green, regardless of the amount of light. Quickly return the cage temperature to room temperature, as even short periods at temperatures above 95° F. may harm the animals.

The children may be puzzled why the anoles change color. They should be able to guess that when the male extends his dewlap, exhibiting the scarlet skin, he assumes a somewhat more awesome appearance than normal and calls attention to himself. The changes of both males and females in response to temperature and light may be related to what the children know about plant life. Recall that these lizards live in trees and bushes, and that at low temperatures leaves usually die and turn brown. In addition, many trees lose their leaves, leaving only the naked brown branches. During this period, the anole tends to be brown. In the summer, the green-colored anole may hide among the leaves. When brown, it may be camouflaged on tree trunks.

If the children have been successful in maintaining a suitable environment for the anoles, the anoles may mate. The female usually lays a few brown leathery eggs in the ground, but in captivity she may lay them on top of the soil. The children can incubate the eggs in the following manner. Barely moisten two sheets of paper toweling and place one on the bottom of a plastic bag. With the fingers, pick up the eggs, place them on the toweling in the bag, and cover them with the other sheet of damp toweling. Inflate the bag and seal it shut with rubber bands. Put this incubator in a dark place where the temperature is between 80° and 85° F. After about 20 minutes, check the bag to see if a mist has formed on it. (If puddles or large droplets have formed, the paper toweling is too wet and the eggs will "drown.") Keep the paper toweling moist by opening the bag every other day and sprinkling some water on it. In about 60 days the young should hatch. These should be kept in a separate terrarium, as the adults may eat them. The young will thrive on fruit flies.

Learnings: (x) Many animals have the same color as their environment, others assume it. This is a protective adaptation, which helps camouflage them, making it difficult for enemies to locate them. The anole changes color with its mood and in response to temperature and light.

Summing Up Ideas: In this section the children learned that animals adapt to their environments in order to survive. Some animals migrate and others hibernate as winter approaches. Others have protective coloration that makes them hard to see and that serves to protect them from their enemies.

HOW DO PLANTS RESPOND TO THEIR ENVIRONMENT?

Growth movements are considered adjustments of a plant to the environment. Growth movements in plants are defined as changes in the position of parts of a plant because of an enlargement of cells or an increase in the number of cells. Some of these movements are known as *tropic* responses of plants to the environment. Among the tropic responses of plants are *geotropism,* a response to gravity; *phototropism,* a response to light; and *hydrotropism,* a response to water. The flowering of plants is affected by the length of exposure to light and is another response to environment. This response is known as *photoperiodism.*

ACTIVITY 25 (x,y)

OBSERVING A PERENNIAL PLANT

Purpose: To provide the students with a long-term project in observation

Concepts to be developed: Many changes take place in a plant during its life cycle. These changes are adaptations for survival.

Materials needed:

Thermometer
Box or Polaroid camera

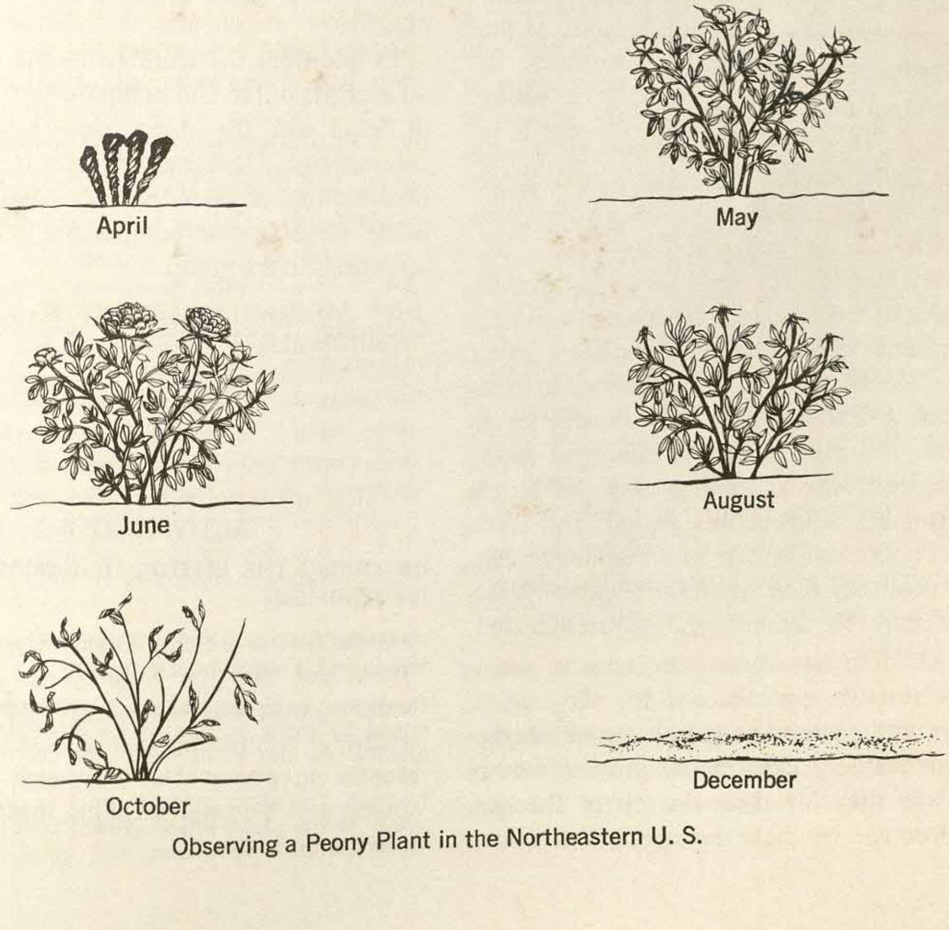
INTRODUCTION: Children can easily observe the life cycle of many plants and the changes which occur in their growth. The plant observed might be a tree in the schoolyard, a weed growing in a vacant lot, or a flower in the garden at home.

Geographic location has a great deal to do with the changes that occur seasonally in a plant. In the northern portion of the United States the changes are quite dramatic, with the leaves dropping from broadleaf trees and the plants in the garden ceasing growth with the first frost of the season. In other parts of the United States changes occur in plants during the year but these changes may not be nearly as noticeable.

The Activity suggested here should be carried on throughout the year. During the fall, shortly after the opening of school, many plants are still in bloom and temperatures are generally moderate. Perhaps the children can locate a peony bed in your community for study. Have the children make observations of the site. One of the children might want to take pictures of the peony bed and include one of his classmates in the photograph to help show the relative sizes of the plants in the area being observed.

They should note the date, time of day, the appearance of the flowers and leaves, the soil temperature (obtained by placing the thermometer approximately 1 inch in the ground), air temperature (measurement made approximately 12 inches above the surface of the ground), condition of the soil (compact or loose), and other pertinent information. Record the observations weekly on a large chart similar to the one illustrated. Children may want to keep a pictorial record of the plants. The photographs taken at the same time observations are made might be mounted on a large chart.

As the fall progresses the children can note the temperature changes. The plants take on a



April

May

June

August

October

December

Observing a Peony Plant in the Northeastern U. S.

different appearance, especially after the first frost, in the northern portion of the United States. After the plants have been killed by frost, have the children keep a record of the air and soil temperature for two weeks after the plants cease to grow. In northern climates the children should make soil and air temperature readings about once a month until evidence of plant growth appears in the spring. Along with the temperature readings, the children might want to keep a record of snow or other precipitation that falls on the experimental plot. Keeping a record of the temperature and precipitation will help the children in drawing conclusions about the adjustments of perennial plants during winter. Children living in southern climates can observe the amount of growth over the winter and make observations weekly during the school year.

In northern regions, as spring approaches, the children should start their weekly observations three or four weeks before the official coming of spring. As spring approaches, the children might compare the soil temperature with the air temperature. How do the temperatures compare? Is one higher than the other? What conclusions can the children draw from temperature comparisons? The children can carefully look at the peony bed to determine when growth starts. In addition, they might want to compare a peony bed that is in the sun all day with one that is in the shade for half a day and a third one that is shaded all day long. Have the children carefully observe the surface of the peony bed to note what has happened to the leaves, stems, and roots of the plant growth of the previous year.

As the spring progresses, the temperature record and the observations of the plants are made weekly. The children might want to prepare a chart of the fall, winter, spring, and early summer observations. (This Activity was based on the peony, a perennial plant that flowers in the spring. You may wish to carry out another activity following the above procedure but observing a perennial, such as the chrysanthemum, that flowers in the fall.)

Learnings: (x) Temperature is a factor in the growth of plants. (x) Seasonal changes influence the growth of plants. A perennial plant changes with the seasons.

ACTIVITY 26 (x,y,z)

OBSERVING A TREE FOR EVIDENCE OF SEASONAL CHANGE

Purpose: (Long-term Activity) To help students gain an understanding that some of the work performed by scientists requires long periods of observation and record keeping

Concept to be developed: Trees change with the seasons as an adaptation for survival.

Have the children select a tree on or near the school grounds to observe during the entire school year. Develop with them the kind of records they might keep. A pictorial record of the tree might be kept for the children's study. In addition to the sketches of the tree's general appearance, the children might want to prepare a pictorial record of the development of the buds and leaves, among other visual observations. Written records can be maintained of air temperature (measured approximately 6 feet above the ground level and other levels if the temperatures can be safely measured), dates of leaf emergence and appearance, condition of buds (sticky, scales, protection), appearance of the bark, leaf coloration during various seasons, and other items selected by the children for their inquiry.

In addition, the children might want to study an evergreen tree and compare these observations in detail with the observations made of the deciduous tree. Have the children make individual observations of trees in their neighborhood and bring these in for comparison with other observations in the group.

Learning: Trees adjust to seasonal changes in various ways.

ACTIVITY 27 (y,z)

OBSERVING THE EFFECTS OF GRAVITY ON PLANTS (GEOTROPISM)

Purpose: To find out that gravity influences the direction in which roots and stems grow

Concepts to be developed: A growing plant is influenced by many factors in its environment, including gravity. As the plant grows, it changes position in response to gravity. This movement is called geotropism. The effect of geotropism is greatest on those areas of the plant where growth occurs, the budding stems and the tips of roots.

Materials needed:

- Two potted plants (bean, coleus, sunflower, or geranium)
- India ink, marking pen, or felt pen
- Ruler
- Cardboard strip

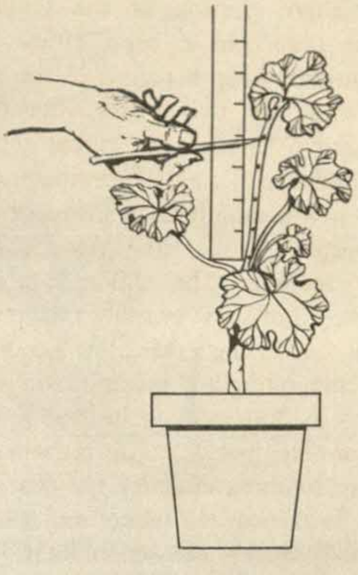
INTRODUCTION: Ask the children to discuss in which direction trees and other plants grow on the slope of a mountain. Do they grow perpendicular to the angle of the slope or to the horizon? Illustrations showing a slope and its vegetation would be appropriate at this time, or a child may draw for discussion two pictures on the chalkboard, one showing trees perpendicular to a slope, the other showing trees perpendicular to the horizon. Ask the children how they would stand on a slope. Is there any relation between their position on the slope and that of the vegetation? As the children become aware that both they and the vegetation stand perpendicular to the horizon, not *the angle of the slope, ask them to explain what force determines the position. Children who have had some previous work in science may know that gravity is exerted upon all matter. The pull of gravity is toward the center of the earth, not toward the center of a mountain.*

As a plant grows it changes position as it is acted upon by gravity. Changes in position caused by gravity are known as geotropisms and are adaptations that enable a plant to survive in its environment. For example, the ability of a plant root to grow downward in response to gravity is beneficial to the life and health of a plant, for the root is thus growing in the direction of soil and ground water.

You may explain to the children that the part of a particular plant organ, such as a root, that responds to environmental conditions is the growing region, which is at the tip of the root. When large concentrations of the growth substances known as auxins accumulate on the lower sides of a root, the growth of the cells in this region is inhibited. The cells on the top, where the auxin concentration is less, are not inhibited and grow and elongate. Thus the root grows downward. The effect on stems is the opposite. Where auxins are in higher concentration, the cells grow. Therefore, stems are negatively geotropic (they grow in the direction opposite the pull of gravity). Since light determines where auxins accumulate, generally an organ that is negatively geotropic is positively phototropic.

The two potted plants used in this Activity should be the same kind so that variations among species will not confuse your results. Each plant should have a main stem about 5 inches tall bearing several leaves.

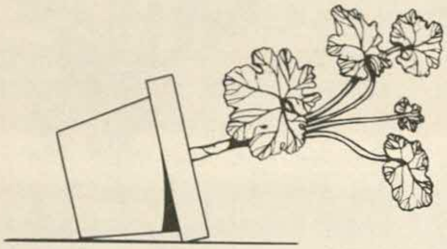
Have the children cut a strip of cardboard about 6 inches long and mark every ½ inch.

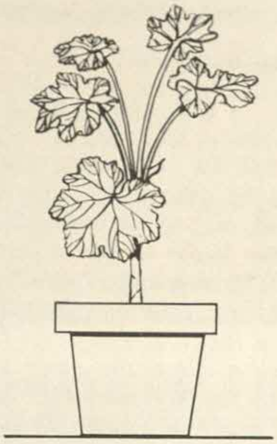


They should then place the cardboard scale against the main stem of each plant and make a mark on the stem every ½ inch. Have them start at the top of the stem and mark down along it for at least 3 inches. Marking may be done with a brush and India ink, or a marking pen.

Have the children place one of the plants in a horizontal position and the other, the control, in a vertical position. The children should be led to suggest that both be placed in a dark room to insure that gravity, not light, causes any changes in position.

Just before the light is turned off, have the children observe the position of the stems in both plants. One effective way to record their observations is to have them sketch each plant. In about three days, have the children return to the dark room. They should observe and record by drawing that the stem of the horizontally placed plant now curves upward. The children should also compare the markings on the stems of both plants with those on the cardboard scale. From their observations, the children can consider the following questions: How does the control plant (vertical) compare with the experimental plant (horizontal)? Where did the greater amount of growth occur? *(Near the tip of the stem.)* Where did the curvature in the experimental plant occur, if any occurred? *(Near the tip of the stem.)* What does this seem to indicate? *(The growing region of the stem is most influenced by gravity.)*



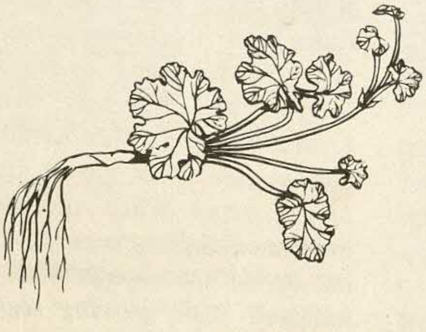


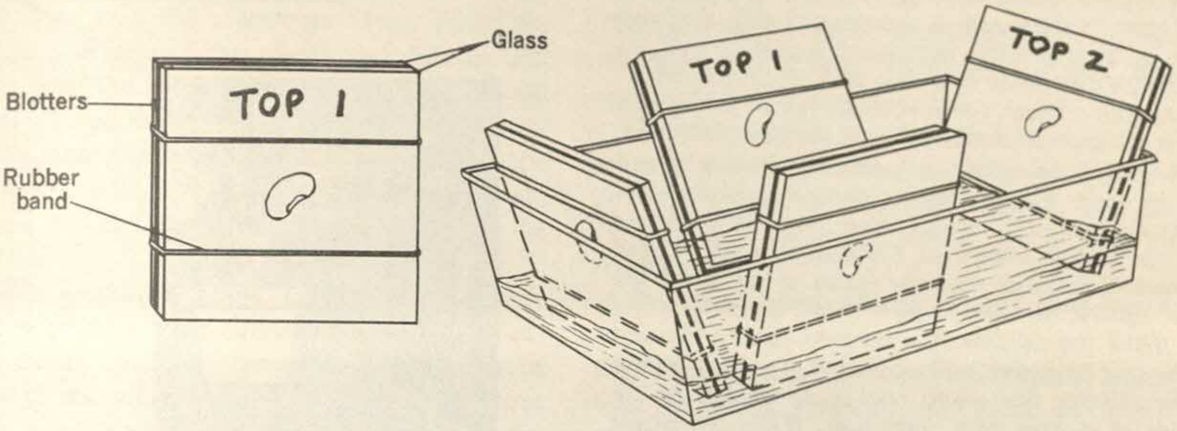
After the children have observed the effects of gravity on the stems, have them remove each plant from its clay pot, soak the packed soil in water, and carefully break the soil away. Caution the children not to break the main, or primary, root of the plant. Have the children examine each primary root to note if there has been any gravitational effect on its growth. *(The root of the horizontally placed plant will have turned downward toward the gravitational pull of the Earth. The root of the vertical plant was already growing in the direction of the gravitational pull of the Earth.)*

Now have the children compare the direction in which the root of the horizontal plant grew with that in which the stem grew. What do they conclude? *(Roots are positively geotropic; they grow toward the gravitational pull of the Earth. Stems are negatively geotropic; they grow away from the gravitational pull of the Earth.)*

Learnings: (y) Plants respond to the gravitational pull of the Earth. (z) Roots are positively geotropic; stems are negatively geotropic.

Additional Activities: The children may experiment with several kinds of plants to see if the geotropic effects vary according to the species of plant. Each child in the classroom can select a different plant and repeat the experiment at home. He or she can maintain records similar to those suggested above and report back to the class. A bulletin board display of all of the records and drawings will help inform all children of the results of individual experiments.





Children who have shown great interest in this Activity may do the following variation at home or in the classroom. They will need four beans (preferably lima beans), blotting paper, eight sheets of glass about 3 inches square, rubber bands, a glass meat-loaf dish, water, and a grease pencil.

Cut the blotting paper the same size as the pieces of glass. On each of four pieces of glass, place two layers of blotting paper. Place a bean that has been soaked in water for 24 hours on each of the four stacks. Cover each stack with a second piece of glass, and hold the "sandwich" together with two rubber bands, as shown in the illustration. Have the children mark the top of each sandwich and number each one, writing on the glass with a grease pencil.

Stand the sandwiches in the meat-loaf dish, which should contain about ⅛ inch of water. (As the water evaporates, put more in to keep the blotter moist.) Have the children check daily to see when the seeds germinate and to note their growth.

When the roots are about ½ inch long, have the children remove sandwiches 2, 3, and 4. On each of these sandwiches have them mark on the glass the position of the root. They may now turn sandwich 2 so that the top is the left side and replace it in the meat-loaf dish. Now turn sandwich 3 so that the top is the right side and replace it in the meat-loaf dish. Have them open sandwich 4 and cut about ⅛ inch off the tip of the root. Replace the cover on sandwich 4. Place it back in the meat-loaf dish, with the top in the original position. The unchanged bean, sandwich 1, will serve as the control.

Each day the children should note the change, if any, in direction of growth of the roots. They will be able to compare easily the new position with the original by noting the marking they made on the glass with the grease pencil. The children should observe that the uncut roots have changed position and are growing downward. The roots whose growing tips were cut off exhibit no change. (If they do, another investigation is in order. How much of a root is growing?)

If the children protest that the roots seem to be growing toward the water in the dish and not in response to gravity, call their attention to the fact that all the water the seeds need is in the blotter. The water in the dish keeps the blotter moist.

ACTIVITY 28 (x,y,z)

OBSERVING HOW PLANTS RESPOND TO LIGHT (PHOTOTROPISM)

Purpose: To discover that the direction in which stems and leaves grow is influenced by light

Concepts to be developed: Stems and leaves grow toward light, an adaptation known as phototropism. The part of a stem that exhibits the greatest amount of turning toward light is the growing tip.

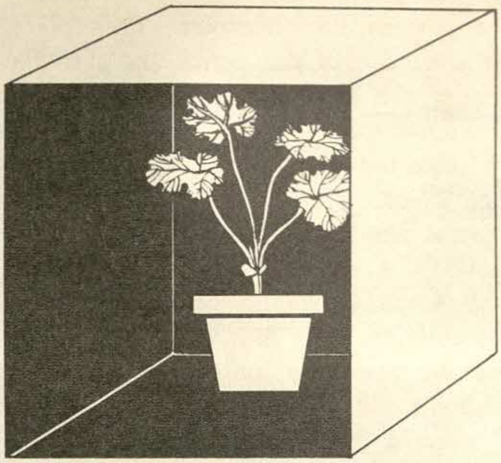
Materials needed:

2 seedlings: bean, pea, or sunflower
1 half-gallon milk carton
Black poster paint
Felt-tip or marking pen
Masking tape

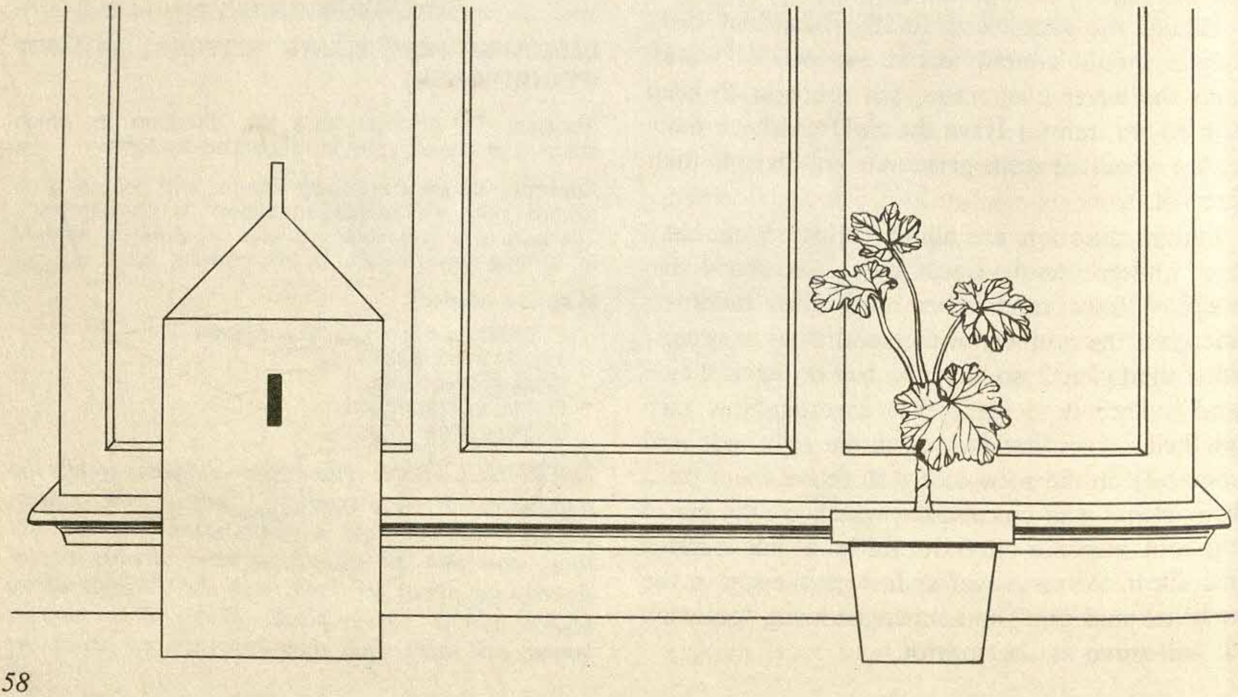
INTRODUCTION: Have the children recall the importance of photosynthesis. They should remember that without light a plant cannot manufacture food, and that all animals depend directly or indirectly on plants for food. Ask the children where photosynthesis takes place. When they suggest leaves, ask them what they have noticed about the *position of leaves growing outdoors.* (Leaves tend to grow in the direction that permits their receiving the greatest possible amount of sunlight.) *Call the children's attention to a vine such as English ivy or woodbine. These vines generally grow flat against a wall, and all the leaves face the same direction. The leaves of maple and oak trees, when viewed from under the tree, almost completely obscure the sky because each leaf has grown in a position where it can receive some light. Children who have visited ponds may recall how the leaves of the water lily are spread over the surface of the water.*

Have the children discuss how a plant grows and the role of auxins in plant growth. You may inform the children that auxins tend to accumulate on the side of a stem away from light. When the auxins become concentrated, they cause the cells in the region to elongate. Because the cells on the light side are not stimulated to elongate, they remain small, and the force exerted by the elongating cells on the shady side causes the shady side of the stem to twist around the small cells and into the sunlight. Since the formerly shady side is now in the sunlight, the auxins migrate away from the newly lighted areas to the shady areas, causing the cells in that region to elongate. Thus the plant is continually turned toward light. This movement toward light, an external stimulus, is called phototropism.

Have the children cut the bottom off a milk carton and paint the inside of the carton with black poster paint. If the children have studied the properties of light, they may be asked why the carton is being painted black. *(Black absorbs light. Thus, most of the light that enters the carton will not be reflected onto all parts of the plant, which would affect the results of the experiment.)*



Using a single-edged razor blade, the children should then cut a narrow slit, about 1 inch long and ¼ inch wide, in the side of the milk carton. (*Caution.* The slit should be level with the top part of the seedling.) When this small "darkroom" is prepared, the children may then mark with a felt pen a ½-inch scale on each seedling, starting at the tip of the plant. At this point the children might want to make drawings or take photographs of the two plants before they are placed under experimental conditions.



Put the plants near each other in a well-lighted part of the classroom. Then place the carton over one of the plants and turn the slit away from the light source. So that no light will enter except through the slit, seal the carton to the table top or the ledge with masking tape painted black. The enclosed plant is the experimental plant, and the uncovered one is the control.

Both seedlings should be watered regularly by the children. The children can water the experimental plant by passing a rubber tube through the slit in the milk carton. After three days, remove the experimental plant from the milk carton and compare it with the control plant. The children may make drawings and compare them with the earlier drawings to discern any differences. Ask such questions as: What happened to the stem of the seedling in the milk carton? How does it compare with the stem of the experimental plant? What are the differences? How do the marks on the stems compare? What position did the leaves of the experimental plant assume? How do the leaves of the control plant look? Are there differences in the two sets of leaves? What conclusion can we draw from this experiment about the response of plants to light?

Learnings: (x) Stems and leaves grow toward light. (y) This response is called phototropism. (z) The part of a stem that exhibits the greatest phototropic response is the growing tip.

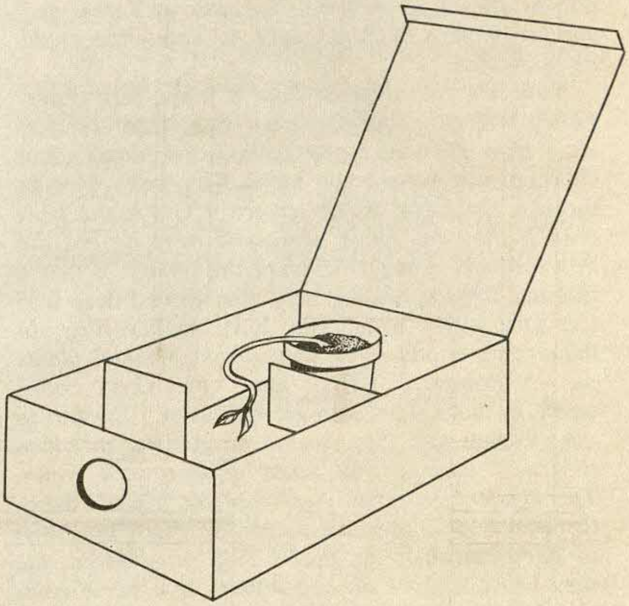
Additional Activities: The Activities below may be used to reinforce what the children have learned about phototropism. Any of the phototropic experiments mentioned here may be varied in innumerable ways, and the children should be encouraged to devise as many variations as possible. However, be sure that the students understand that in order to investigate an idea, such as that plants tend to grow toward light, they should carefully design their investigations so that their conclusions are accurate.

Several children working together, or the whole class, may investigate whether all kinds of plants respond phototropically at the same rate. The children may test fast-growing plants, like beans and peas, and slower growing species, like geraniums. (Check with your local nursery for additional species and their growth rates.) The children should be encouraged to keep accurate records of their observations so that their comparisons will be meaningful.

Geranium leaves on the same stem form a mosaic, or pattern arranged in the same plane. A small group of interested students can investigate how the entire mosaic pattern may be reoriented.

The children should obtain a healthy potted geranium plant bearing several leaves. Then they should get a cardboard box slightly larger than the potted geranium, and paint the inside of the box with black poster paint. Set the geranium well back into the box and place the box so that sunlight strikes the open side. In a few days the leaves will have turned toward the light.

The following variation interests many students because of its puzzle-like aspect. Obtain a long narrow box with a lid, such as a shoe box. The box should be deep enough to contain a potted bean seedling about 3 inches tall. Make a maze out of the box by taping two sheets of cardboard in it, and cut a large round hole in one end of the box. Put the pot behind the cardboard sheet that is farther from the hole. Cover the box and turn it so that the hole faces direct sunlight. The box may be uncovered for short periods so that growth tendencies may be ob-



served and so that the plant can be watered. The children should keep a record of how long it takes for the bean shoot to reach the hole. Did it grow directly toward the hole or twist and turn within the compartments before it reached the opening?

ACTIVITY 29 (x,y,z)

OBSERVING THAT ROOTS GROW TOWARD WATER (HYDROTROPISM)

Purpose: To find out if roots grow toward water

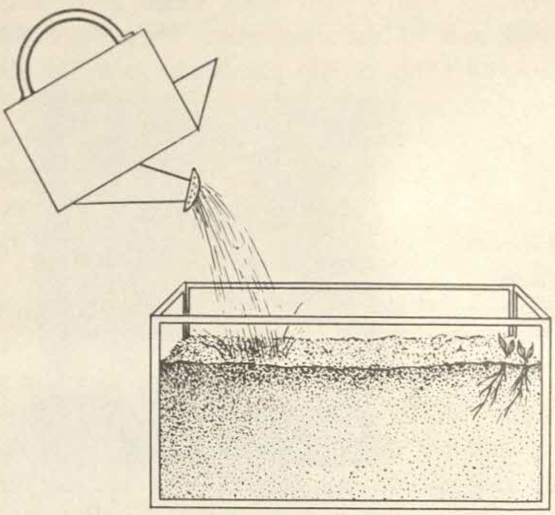
Concepts to be developed: Roots grow toward water, an adaptation called hydrotropism. One of the important functions of roots is to absorb water for plants. Most of the water is absorbed by small hairlike structures called root hairs.

Materials needed:

Radish seeds
Glass aquarium about 2 feet long (do not use a round one)
2 flat pans about 2 feet long and 4 inches deep
Potting soil
Water

INTRODUCTION: Discuss with the children what happens to vegetation during a prolonged dry spell in the summer. Point out that at first vegetable and flower gardens stop growing, and eventually they may turn brown and die. Mention that grasses and the leaves on bushes and trees may also turn brown. The discussion might be accompanied by pictures showing that after many years of drought the land has become dry and parched and that practically all vegetation has died off. Pictures of the desert might also be shown. A picture of an oasis with trees and another picture of dunes with no vegetation could be contrasted.

Now ask the children how a plant gets water. (They will probably say from rain, from brooks, etc.) *How does the water get into the plant?* (The children may have many ideas. The water goes in through the roots, which absorb it.) *Ask the children if they can guess why most trees do not die in a seasonal drought.* (One of the reasons is that a tree has large spreading roots that extend deep into the soil, where water may have sunk.) *Why do many grasses and other annual and biennial plants die in droughts?* (They may have short roots, which do not extend into ground water.) *Suggest to the children that they can do an Activity in which they will observe that roots grow toward water. This tendency to grow toward water, called* hydrotropism, *is an important adaptation that contributes to the survival of the plant. Tell the children that they will also have an opportunity to observe roots closely and to see the parts of the roots that absorb water.*



Fill the aquarium about ¾ full with soil, packing it loosely. Have the children plant about five seeds near one end of the aquarium next to the glass. The seeds should be placed about ½ inch beneath the surface. Moisten the soil carefully so that it will not be too wet for successful germination. When the seeds have sprouted (within a few days), remove all but two of the plants so that the remaining ones will have room to grow and will be able to get plenty of nutrients from the soil. From this point, water the aquarium only at the end opposite that where the seedlings are growing. The end where the seedlings are growing will become dry.

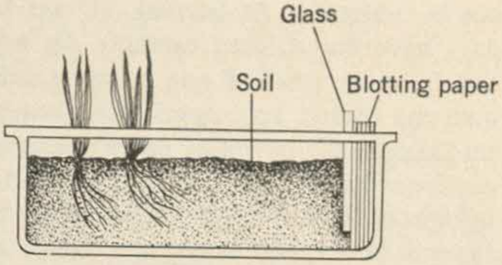
For the next few weeks, have the children observe the plants. See if they can discover that the roots grow toward the watered end of the aquarium. When the roots are well developed and are obviously growing in the direction of the water, have the children dig up the plants very carefully to avoid tearing or damaging the roots. Have them examine the roots (a magnifying glass will provide better observations than the naked eye). Ask them to describe what they see. *(If the plants have been dug up very carefully, they should see tiny threadlike structures projecting from the roots.)* Tell the class that these structures are called root hairs and that root hairs provide more surface for the diffusion of water into the root. These root hairs push through air spaces in the soil, increasing the probability of contact with water and dissolved minerals.

Learnings: (x) Roots grow toward water. (x) Water is absorbed by small extensions of the root known as root hairs.

Additional Activities: To demonstrate that the roots of most kinds of plants tend to grow toward water, several children may be encouraged to try a variation of the above Activity. Soak corn kernels and various kinds of peas and beans overnight. Obtain several glass baking dishes or plastic containers of the type used to store fresh vegetables in the refrigerator. Make a pack of blotters about ½ inch thick to fit the end of the container, and, with a sheet of glass or heavy plastic, press the blotter pad against the end of the dish. Fill the rest of the dish with loosely packed soil, and plant about four radish seeds near the side of the container. Sprinkle the entire set-up with water for a few days, until both shoot and root are growing well. Then stop watering the soil, pull up the glass divider about 1 inch from the bottom, and water the blotter pad until it is just moist. Keep the blotter pad moist, and observe the direction in which the roots grow.

The children may make fairly accurate comparisons of daily changes in movement by marking the glass container with crayons of different colors. For example, the first mark—in red crayon—could be the position of the root when the soil is watered. The second mark—in green—could be the position of the root two days after only the blotter pad is moistened, and so on.

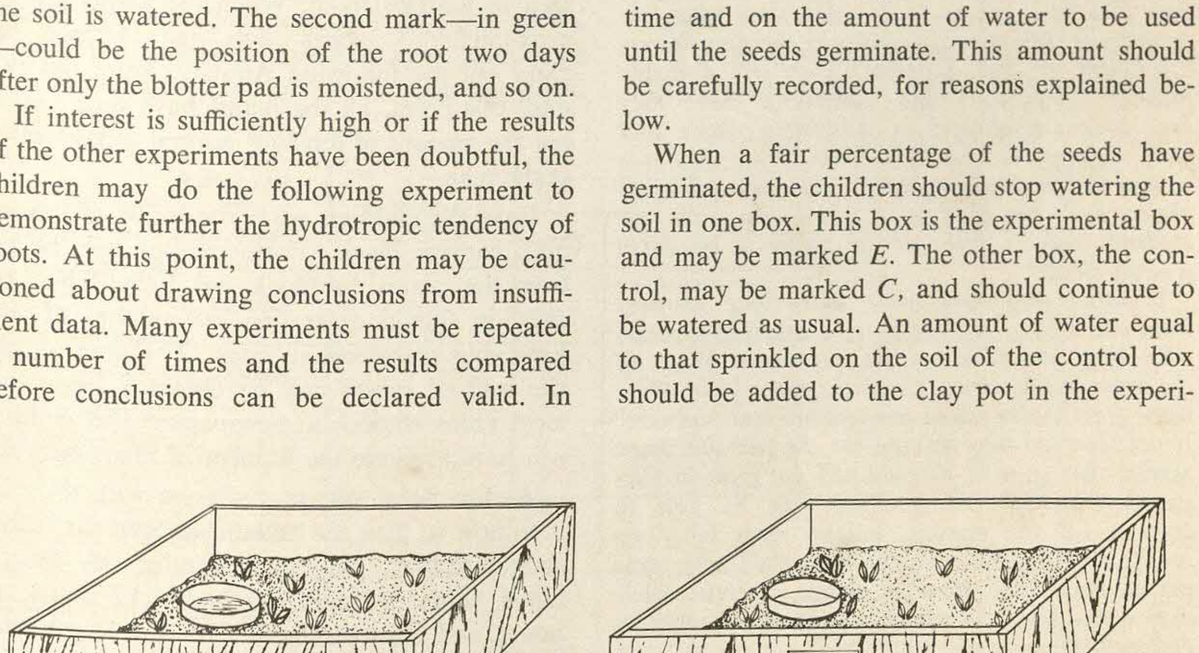
If interest is sufficiently high or if the results of the other experiments have been doubtful, the children may do the following experiment to demonstrate further the hydrotropic tendency of roots. At this point, the children may be cautioned about drawing conclusions from insufficient data. Many experiments must be repeated a number of times and the results compared before conclusions can be declared valid. In experiments with hydrotropism, for example, the plants will sometimes die, and no result of positive hydrotropism can be noted.



Materials necessary for the following Activity are two wooden boxes about 2 feet square and 6 inches deep, sandy loam soil, two clay pots 4 inches tall, two cork stoppers, and several seeds each of corn, peas, and beans.

Have the children place about 1 inch of sandy loam soil in each box. At one end of each box place a clay pot with its hole plugged with a cork. Then fill the rest of the boxes with soil, taking care not to drop soil into the pots. In each box, plant the same number of seeds of corn, peas, and beans at various distances, ranging from ½ to 15 inches from the clay pot. Plant the seeds in the same pattern in both boxes. Have the children water the soil lightly twice a day. The children should agree on a uniform watering time and on the amount of water to be used until the seeds germinate. This amount should be carefully recorded, for reasons explained below.

When a fair percentage of the seeds have germinated, the children should stop watering the soil in one box. This box is the experimental box and may be marked *E*. The other box, the control, may be marked *C*, and should continue to be watered as usual. An amount of water equal to that sprinkled on the soil of the control box should be added to the clay pot in the experi-



mental box. (The clay pot in the control should not be watered.) At intervals of two to three days have the children carefully dig away the soil from the roots of one or two seedlings in both the control and experimental boxes. They should note the extent of development and the direction that the roots tend to grow. After six to eight days, have the children compare the root systems in the two boxes and sketch the appearance of the roots.

ACTIVITY 30 (x,y,z)

STUDYING HOW THE LENGTH OF EXPOSURE TO LIGHT AFFECTS FLOWERING (PHOTOPERIODISM)

Purpose: To discover that the length of time a plant receives light helps determine whether or not it will flower

Concept to be developed: In order to flower, a plant must receive a certain amount of light.

Materials needed:

5 cardboard milk cartons (½ gallon or 1 gallon size)
Black poster paint
6 potted plants (salvia, if possible)
100-watt bulb

INTRODUCTION: Have children discuss how higher plants reproduce. They will probably remember that a higher plant reproduces by flowering. Point out that if a species does not flower, it dies. Children who have gardens are probably familiar with the fact that some flowering plants thrive in their area while others do not. Ask them what factors they or their parents consider in choosing flowering plants for their gardens. (They will probably mention temperature and moisture.) *Have they ever been unsuccessful in cultivating plants that were supposed to be easy to grow? Have they ever wondered why their neighbor can grow luxurious blossoms in the shadow of his house while the students couldn't even get the plants to bloom in a sunny place?*

Children who have made fairly long journeys from one area to another may be asked to describe what they noticed about the vegetation. Were all the trees and flowering plants the same kind? Were there great variations in temperature and moisture? If not, how do they account for the fact that some species that grow in Virginia will not grow in Vermont? (Students will probably not be able to account for the reasons. Indeed, until fairly recently, scientists were unable to explain why some plants would not grow in certain latitudes while they would thrive in similar conditions of moisture and temperature at other latitudes.)

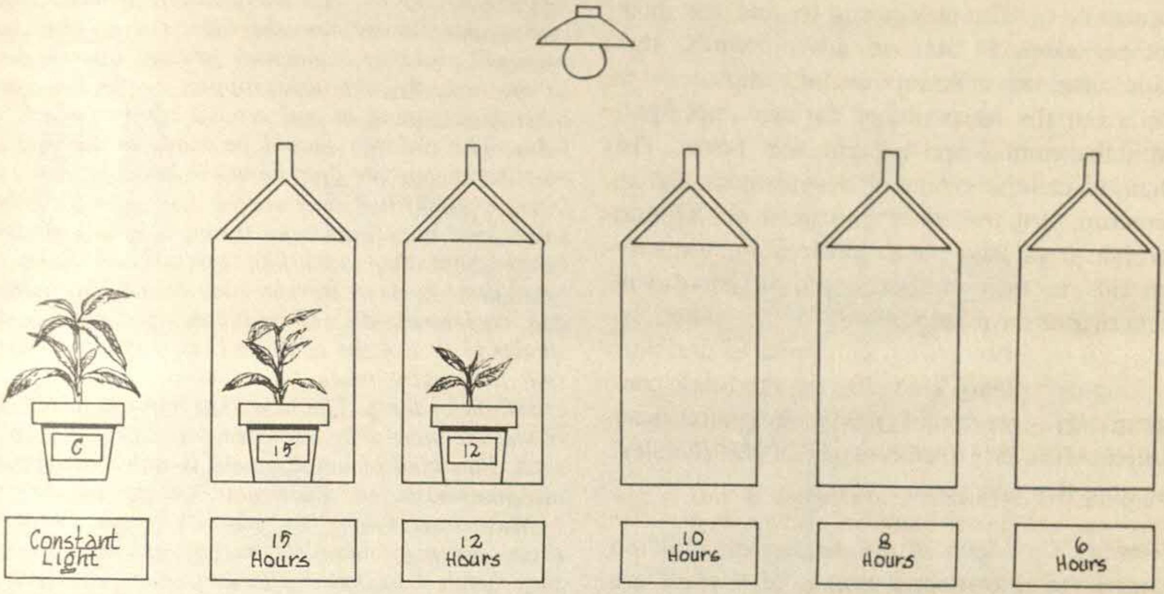
You may explain to the children that the amount of time a plant spends in light and in darkness determines whether or not it will flower. Therefore, goldenrod will flourish in one area, but farther north or south it doesn't grow at all. Although the temperature and the amount of moisture may be similar in these different latitudes, the amount of daylight and darkness is not. The greater the distance from the equator, the greater the variation in the length of day. In the center of the Temperate Zone, the shortest day has approximately 9 hours of sunlight and the longest day has about 15 hours of sunlight. Certain species are adapted to flower when days are short and others are adapted to flower when days are long. In addition, the location of a plant in a yard determines the length of daylight it will receive.

Plants may be classified as "short-day plants," "long-day plants," and "indeterminate." This means that short-day plants—like poinsettia, cosmos, aster, and ragweed—will often not produce flowers under long-day conditions. They may grow profusely, but they will not flower. Conversely, long-day plants—like wheat, spinach, and sunflower—will generally not flower under short-day conditions. The length of day does not seem to influence the flowering of indeterminate plants, like the tomato.

The children can prepare a rather simple experiment to study how the length of exposure to light affects the flowering of plants. Obtain six potted seedlings, preferably salvia, one of the plants most widely used to demonstrate photoperiodism. Salvia seedlings may be purchased at a greenhouse, or the plants can be grown from seed in the classroom. When the plants are approximately 3 inches high, the children can carry out the following Activity. Point out that until this point, all the plants have been receiving the amount of daylight normal to the season of the year.

Have the children paint the inside of the five milk cartons black. These cartons will be put over the plants to block out light. Then the children should determine the amount of sunlight your classroom receives. The time of sunrise and of sunset can be obtained from your local radio station or newspaper. The children will have to figure the number of hours between.

At this point you may discuss with the children how to plan the amount of light that salvia should receive. The recommended day lengths are 6 hours, 8 hours, 10 hours, 12 hours, 15 hours, and constant light. The day length may be controlled by covering each plant after it has received its recommended amount of light. For the 10-, 12-, and 15-hour light exposures, the



children may have to use artificial light. A 100-watt bulb should be used for this purpose. This Activity should probably be carried out as a home project rather than as a classroom project, since many schools will not permit the use of electric lights after school hours.

The plant to receive 6 hours of light should be uncovered for only 6 hours during the day. The plant to receive 8 hours of light should be uncovered for only 8 hours per day, and so on. The plant receiving constant light should be placed under an electric light during the night.

Learning: (x,y,z) The flowering of many plants is determined by the amount of time the plant spends in light and in darkness.

Additional Activities: There are many important commercial applications resulting from the study of photoperiodism. By controlling the amount of daylight, a nursery can prevent flowering until all the plants are ready to produce flowers.

A group of children may visit an agricultural station where studies of photoperiodism are being

AMOUNT OF DAYLIGHT	DATE EXPERIMENT BEGUN	DID IT FLOWER?		DATE FLOWERED	NUMBER OF DAYS EXPOSED
		YES	NO		
6 HOURS					
8 HOURS					
10 HOURS					
12 HOURS					
15 HOURS					
CONSTANT					

conducted, or visit a nursery to find out how photoperiodism is used to grow orchids, carnations, and other flowers out of season.

It is actually the period of darkness, not light, that determines when a plant will flower. An advanced child who wishes to investigate photoperiodism further may be informed of this and directed to do additional research on the subject. He may write the state or U.S. Department of Agriculture for information. If he wishes, he may also try interrupting the period of darkness on long-day plants blooming in short-day conditions. The results of this investigation may stimulate him into further study of the chemical reactions that take place in plants.

Summing Up Ideas: In this section the children learned that growth movements of a plant are adaptations for survival. The stems and leaves of green plants grow toward the light and away from the center of the Earth. The roots of plants grow toward the center of the Earth and toward water. The flowering of plants is related to the amount of time the plant spends in light and in darkness. Different species of plants will flower under different conditions of light and darkness.

ADVANCED ACTIVITIES

The following Activities have been included for the teacher who would like to provide some of her more interested students with additional topics to investigate. They may be used in the classroom with groups of students who are especially interested in science and who have the ability to carry on the project without too much direction.

ACTIVITY 31 (z)

OBSERVING THE LIFE CYCLE OF THE MOSQUITO (METAMORPHOSIS)

Purpose: To observe the adaptations of the various stages in the life cycle of the mosquito

Concepts to be developed: Mosquitoes and most other insects go through a complex life cycle in which they change form three times. This life cycle is called "complete metamorphosis." The immature forms are different in structure and function from the adult, and usually live in different environments.

Materials needed:

- Pond water
- Mosquito larvae
- Large test tubes
- Cotton wadding

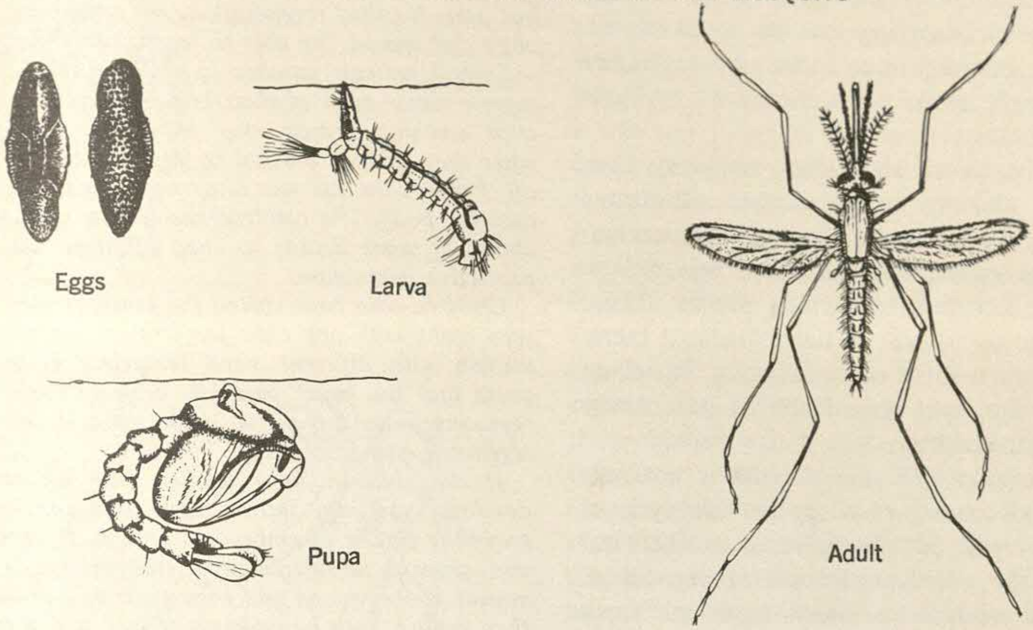
INTRODUCTION: Ask the children to name some insects and discuss how the insects live. The children will probably begin with familiar insects, such as the housefly, ant, grasshopper, beetle, bee, and other kinds found in and around the house and in fields. The children should be made aware that in most cases they are describing the adult form of the insect. Ask them if they are familiar with the other stages that most insects go through. Many children believe that tiny adult-like insects hatch out of eggs. Some kinds of insects, such as the grasshopper and cockroach, do. They hatch in a form quite similar to that of the adult and, as they grow larger, split their skins when these become too tight and crawl out of them. The new skin hardens in the air. When the new skin becomes too tight, it also is shed. This kind of development is called incomplete metamorphosis, or incomplete change of form.

Most insects—in fact almost 90 per cent of them—undergo complete metamorphosis; that is, they hatch into forms that are quite different in structure and function from the adult form into which they eventually grow. The immature and the adult forms may live in different environments and have different ways of obtaining food and protecting themselves. The children may have seen some of these immature forms but not recognized them as insects. The caterpillar, for example, is the larva, or immature form, of a butterfly or moth. It does not have the same structure as the adult, nor does it live in the same manner. The function of a caterpillar is to eat and grow, thus providing the next stage—the pupa—with enough energy to change into the mature form, the butterfly or moth. The function of the mature form is to reproduce itself and thus the species. The wrigglers that the children see in ponds or in places where there is stagnant water are the immature forms of the mosquito. The maggots found in garbage pails are immature flies. Tell the children that they are discussing one of the most amazing adaptations on the part of any animal—the changing of form that enables the immature insect to exploit one kind of environment while the adult exploits another. Inform the children that they are going to study one familiar insect—the mosquito—and learn how it changes as it passes through its life cycle.

Have the children bring in some water containing wrigglers, or mosquito larvae, from ponds, stumps of trees, tin cans, abandoned automobile tires, vases, or any other place where stagnant fresh water is likely to be found.

The children may transfer the larvae into a large test tube and put the tube in a place where it will receive indirect sunlight. Have the children observe the larvae. Note how rapidly they jerk around the water. If they are still, tap the tube

STAGES IN THE LIFE CYCLE OF THE MOSQUITO



gently with your finger. Discuss with the children how larvae live. *(They eat organic material suspended in the water. They breathe through the tube on the posterior end.)* You may ask the children to recall that mosquitoes and their close relatives, the flies, are the major insect carriers of human diseases. Lead them to suggest that mosquito populations may be reduced by dehydrating stagnant breeding grounds or covering them with oil. Ask them how this might affect the larvae. *(Without their watery environment, they would die. If oil were poured over the water, they could no longer breathe because the oil forms a thin layer over the water, cutting the larvae off from air.)*

Have the children record when the larvae are brought into the classroom, and tell them they are going to count the number of days it takes for the larvae to change into pupae. *(A mosquito larva changes into a pupa in about one week.)* Each day the children should discuss what changes seem to be occurring.

As soon as a pupa is formed, stopper the tube with loosely packed cotton wadding. Notice that the pupae are very active. Tell the children that this is unusual. The pupae of most insects do not move about, but remain quiet as they change into the adult form. Have the children again observe and record any changes in form. In about three days they will see the pupae change into adult mosquitoes.

The children should compare the adult form with the previous stages. Discuss how wings help the adult perform its function, the reproduction of the species. The children should look for differences in the adult mosquitoes. Males have prominent, hairy antennae and females have threadlike, nearly naked antennae. Have the children guess what the males use their antennae for. *(The numerous sensitive hairs are used in hearing. Hearing helps the males locate the females.)* The children should note the long tubelike proboscis of the female. They undoubtedly know that she uses it to pierce the skin and suck the blood of humans and many animals. Point out that blood is necessary food for the development of her eggs, which she will lay in some other watery place, thus beginning a new generation of mosquitoes.

Learnings: (z) Most insects go through a complex life cycle known as metamorphosis. The immature forms are different in appearance, function, and way of life from the adult forms.

Additional Activities: For further study of complete metamorphosis, the children may raise mealworms, the larvae of the Tenebrio beetle. Mealworms are sold in pet stores as turtle food. To make a home for them, the children should put some cornflakes into the bottom of a large glass jar. The environment may be kept suitably moist by occasionally adding a bit of banana. In addition to observing the life cycle of the mealworm, the children could investigate the behavior of these larvae when stimulated by light, touch, heat, etc.

If you live in an area where mulberry trees grow, the children may cultivate silkworms. Silkworms, which may be obtained from a scientific supply house, spin beautiful pale yellow or white cocoons in which to pupate. These cocoons are the source of natural silk, a fabric prized for dresses and other garments. Watching the caterpillar spin its cocoon is particularly fascinating to children.

Children who live near the desert not only have an opportunity to study the life cycle of the yucca moth, but also have an excellent example of the interdependence of living things. The yucca moth takes pollen from one yucca flower and carries it to another. Here she pushes the pollen against the stigma of the flower and then lays a few eggs in the ovary of the flower. When the larvae hatch, they eat a few of the seeds and then tunnel out of the plant and fall to the ground to pupate. Without the moth, the yucca would not be pollinated; and without the plant, the moth would have no food for its larvae.

ACTIVITY 32 (z)

OBSERVING THE LIFE ACTIVITIES AND REGENERATION IN HYDRA

Purpose: To study the food-getting habits, reproduction, and regeneration of the hydra

Concepts to be developed: Hydras are small fresh-water invertebrate animals. They are carnivorous and capture their prey with stinging tentacles. Hydras may reproduce sexually and asexually. They are able to regenerate lost parts.

Materials needed:

- Hydras (ordered from a supply house or obtained from a pond)
- Jars
- Pond water or rain water
- Test tubes
- Medicine dropper
- Small crustaceans (Daphnia, brine shrimp from pet shop)

INTRODUCTION: Ask if any child has a cut, scratch, or burn that has removed part of the skin. Discuss what will eventually happen to the wounded area. Most children know that skin is replaced as the wound heals. Tell them that, in humans, parts of muscles and nerves will also regrow, as long as the loss has not been too great. This regrowth of lost parts is called regeneration. All organisms, both plant and animal, are able to regenerate some parts.

Several animals familiar to children are able to regrow major parts of their bodies. Boys who have tried catching lizards may have discovered that when they grasped a lizard by the tail, the tail came off. Perhaps the tail was also more brightly colored than the body. The children should discuss how the ability of some lizards to snap off their tails is a protective adaptation.

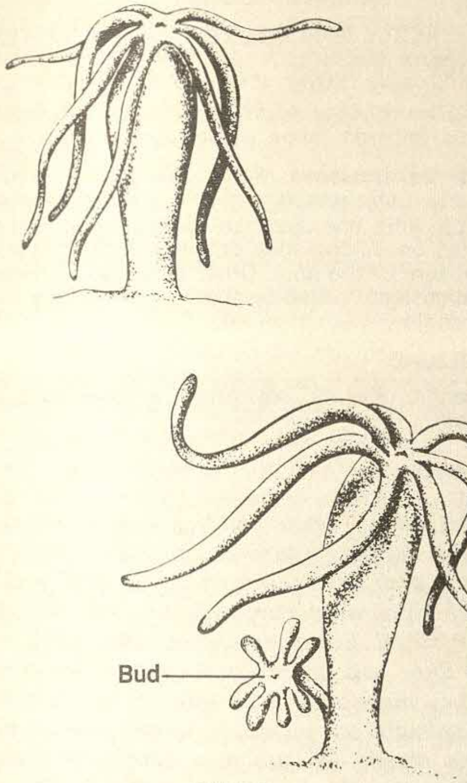
Children who have visited the seashore may have seen crabs with one claw larger than the other or starfish with different sized tentacles. They may guess that the small part has been regrown, thus replacing a lost organ. A single tentacle can even regenerate a whole starfish.

If the children have studied how an embryo develops, you may inform them that regenerative growth is similar to embryonic growth. In regenerative growth, undifferentiated (unspecialized) cells appear at the wound and then grow and divide. As they mature, they become specialized and form the missing organ. Throughout their lives plants have areas of undifferentiated cells. Have the children suggest some examples of regeneration among plants. As a clue, ask them what plant organs a deciduous tree sheds in the fall and replaces in the spring. Children who have had gardening experience probably know that whole plants can be grown from stem cuttings.

Tell the children that they are going to study the hydra. They will learn how its survival depends upon the ability of the total organism to function effectively. They will learn how regeneration restores an incomplete hydra to a form that will permit it to function as effectively as possible in its environment.

Hydras are small semitransparent fresh-water relatives of jellyfish and sea anemones. Like their relatives, they are invertebrate (no backbone) and carnivorous. They consist of a saclike digestive cavity, the mouth of which is surrounded by stinging tentacles. When fully extended, a hydra may measure about ½ inch from top to tip. Tell the children that they are going to study some of the ways by which this small creature is adapted to life in the water.

The children may obtain hydras from ponds or other still water by collecting totally or partially submerged plants. These plants should be placed in large jars filled to the brim with water from the source of the plants. Keep the jar out of direct sunlight, and keep the temperature of the water below 75° F. Put some Daphnia, brine shrimp, or other small crustaceans into the



HYDRA

jar. If hydras were on the plants, the children will find some attached to the walls of the jar within a day or two. If hydras are obtained from supply houses, they may be raised in rain water.

With hand lenses, the children should examine the hydras on the jar, taking care not to tap the jar with the lenses. Have them describe and draw a hydra, noting the position of the base and the tentacles. Ask them how the hydra is attached to the jar. Some children may guess, correctly, that the base exudes a sticky substance that adheres to the glass. Ask the children how they think such a small animal is adapted to defend itself against predators. The children should recall that the hydra has stinging tentacles and can defend itself with them against animals slightly larger than itself. Ask how it defends itself against still larger animals. The children probably won't know, so have a child tap on the glass or move a pencil through the water toward a hydra. The children will see the hydra quickly contract to about one-twentieth its extended size. They will note that the hydra is now relatively inconspicuous.

As the children are examining the hydras under hand lenses, they may see protrusions on the sides of a hydra's body. Have the children concentrate on these carefully and describe them. When they note that the protrusions seem to be bearing tentacles, you may inform them that this is one way in which the hydra reproduces. This kind of reproduction, called budding, is asexual; that is, the new individual is being produced from only one parent. When the new individual has matured and has fully developed tentacles, it drops off the parent and lives independently. Sexual reproduction also takes place in nature, usually in the late fall or early winter. Sexual reproduction is difficult to observe, however, and if the children wish to study it further they should consult a reference book. The children should discuss how budding helps insure the survival of the species, but they should also understand that sexual reproduction is a more advantageous adaptation than asexual reproduction. In asexual reproduction the new individual is exactly like the parent, and it may have inherited defects that hinder its chances of survival. In sexual reproduction the possibility of inheriting defects is reduced because different cells contribute to the genetic make-up of the individual. Usually the gene that is more beneficial to the survival of the species predominates over the weaker gene.

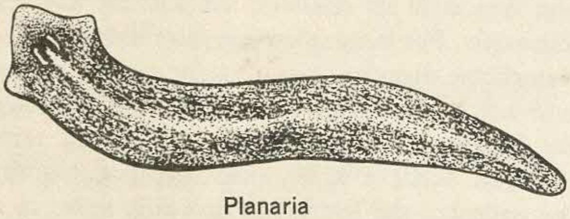
The feeding habits of hydras are interesting and typical of its relatives, the jellyfish and sea anemones. For better viewing, the children, using a medicine dropper, may transfer several hydras into a test tube 1 inch in diameter. Observe how the hydras attach themselves and extend their tentacles. After a while, when no food touches the tentacles, the hydra will probably move to a new location, thus increasing its chances of coming into contact with food.

Have the children find out the hydra's methods of locomotion. *(Usually, the hydra will somersault or inch along like a caterpillar to a new location.)* After the children have observed the locomotion, have them put some small crustaceans into the test tube. The children should notice that the hydra does not chase these crea-

tures but remains stationary. When a crustacean brushes against the tentacles, it is immediately paralyzed by the sting cells along the tentacles. Using the tentacles, the hydra will push the food into its body cavity, where digestive juices will break it down into substances that can be used by the cells. The children should be able to follow this process with their lenses and may be able to see the food inside the cavity.

One of the most interesting adaptations of hydras and their relatives is the ability to regenerate lost parts. Have the children transfer a few hydras onto a white saucer or watch glass. Using razor blades, they may cut the hydra in two or remove a couple of tentacles. With tweezers, or medicine dropper, the children should put each part in a separate test tube so that they can determine which parts regenerate. Tentacles will grow again, and a "headless" body will regenerate a new head. The other parts may not regenerate. Ask the children why regeneration is an advantageous adaptation.

Learnings: (z) Hydras reproduce asexually and sexually. They are able to regenerate lost tentacles and the entire "head." The ability to regenerate lost parts helps them survive by replacing the defensive and food-getting structures.



Planaria

Additional Activities: Children who wish to investigate regeneration further may order planarians, flatworms that are carnivorous invertebrates, from a scientific supply house or try to catch them in a pond. To catch them in a pond, stand on the shore or a dock and hang fresh bits of raw liver from a string. When the planarians come to feed, scoop them up with a dip net and immediately transfer them to a jar filled with pond water. The planarians may be cultivated in the same manner as the hydras. Have the children design their own investigations and suggest that they do some library research to find out which parts of the planarians regenerate and how they do so.

ACTIVITY 33 (z)

STUDYING HIGHLY SPECIALIZED KINDS OF INTERDEPENDENCY

Purpose: To learn about highly specialized dependent relationships between some plants and animals

Concepts to be developed: Some plants and animals are relatively independent; others live in intimate relationships with one another. Some living things are parasites on others; they obtain food and shelter to the detriment of the host. Other plants and animals live in relationships, called symbiotic, from which they mutually benefit.

Materials needed:

Peas, beans, peanuts, soybeans, or other legumes
4 clay pots
Soil
Legume seeds

INTRODUCTION: Most children are aware that all organisms depend on their environment and other organisms in their environment for food and shelter. Ask the children what they consider the most independent of all living organisms and why they think so. They will probably suggest green plants because they make their own food. Have them recall that animals eat plants or other animals that have eaten plants. Discuss how animals get their food. (They may lure it to them, hunt after it, or migrate until they find it.)

Most of the plants and animals that the children have studied or will be raising for study in the classroom are relatively independent; they either make their food or range about looking for a wide variety of suitable forms. Tell the children that several kinds of plants and animals are limited in their choice of food and shelter and must live in very close relationships with these sources. The children are going to study some of these dependencies. They will learn about parasites and organisms that live symbiotically.

Parasites are plants or animals that live off other living organisms to the disadvantage of these organisms. Ask the children if they have ever seen dodder or mistletoe. These green plants, although they carry on photosynthesis, live off other plants. They send specialized roots down into the food-conducting chambers of their hosts and rob them of food and water. The deprived host does not benefit from the presence of these parasites. If too much material is removed, the host plant is damaged and may die.

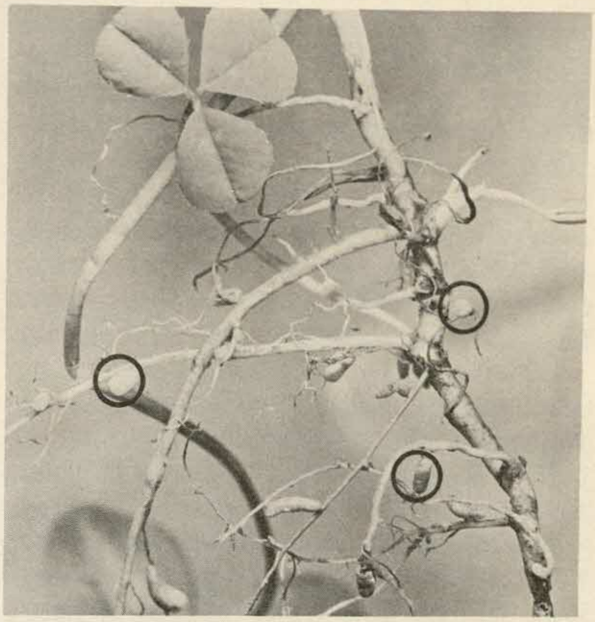
The children are probably familar with a number of parasitic animals without realizing that they are parasites. Children who own dogs and cats know that fleas, ticks, and lice may inhabit their pets. These insects suck blood, but generally do not take enough to harm the host. If the children protest that these pests sometimes cause disease, you may inform them that it is generally not the insect itself that produces the disease, but other *parasites within the insect. Ticks may carry microorganisms that cause severe diseases, like Rocky Mountain spotted fever. When the tick bites its host, some of the microorganisms may pass from the tick into the tick's host. One of the worst epidemics in history—the Black Death, which killed almost half of the population of western Europe in the fourteenth century—was caused by a bacterium that normally parasitizes fleas that normally parasitize rats and other mammals.*

Using the diagram, the children can study how a disease-causing parasite passes from host to host. Malaria, a severe disease characterized by intermittent fevers, is caused by the protozoan Plasmodium. This microorganism must parasitize two kinds of hosts, a warm-blooded animal and the Anopheles mosquito. Plasmodium goes through a life cycle consisting of both sexual and asexual generations. The asexual forms invade the red blood cells of man, where they grow and multiply, destroying the blood cells in the process. Many mature into sexual forms. When the mosquito bites man, it may suck up these sexual forms along with blood. These cells mate in the mosquito's stomach and form cysts in which hundreds of tiny asexual forms develop. The cysts break open and the asexual forms travel to the mosquito's salivary glands and penetrate them. There they are ready to pass into the bloodstream of the next person the mosquito bites. Without the two kinds of hosts, Plasmodium could not complete its life cycle. Ask the children whether or not this parasite helps or harms its hosts. Using this example, the children may summarize the relationship between a parasite and its host.

There is another kind of dependency that is beneficial to both host and guest. This mutually beneficial relationship is called symbiosis. Our bodies contain a number of helpful bacteria. In return for food and shelter, these bacteria help us synthesize vitamins and break down food. Cows and other ruminating animals support bacteria that help convert plant proteins into the kinds of proteins needed by animals. A cow not infected with these bacteria would soon die of malnutrition, even though it ate plenty of grass and other fodder. Termites consume wood, but it is the protozoa in their intestines that digest the woody materials for them.

Tell the children that they are going to experiment with one kind of symbiotic relationship in class: the relationship between nitrogen-fixing bacteria and their hosts, leguminous plants.

Several children can scout fields for clover, soybeans, and alfalfa, or they can look for cultivated peas, beans, or peanuts. When they have located one or more kinds of these leguminous plants, instruct them to ask permission, if necessary, to dig up the roots. If the scouts find noticeable swellings on the roots, have them pack the roots in damp soil in milk cartons and transport them back to class.



Nodules on the roots of a clover plant, circled in the above photograph, contain nitrogen-fixing bacteria.

In class, carefully wash off the roots under slowly flowing water. The children will see that the roots of the legumes, unlike the roots of most of the other plants they have been studying, have swellings on them. Inform the students that these swellings, called nodules, contain thousands of tiny plants called bacteria.

Bacteria do not make their own food; they depend upon other organisms for it. Frequently the food-getting activities of bacteria cause the host, or organism on which they live, to become diseased and die. Point out that tuberculosis, scarlet fever, diphtheria, and pneumonia are human diseases caused by bacteria. Sometimes, however, bacteria help their hosts. Those that live in nodules, for example, do take food from their hosts, but they also provide their hosts with valuable substances the hosts cannot obtain for themselves. The bacteria take up the gas nitrogen from the air and convert it into a form that can be used by the plant. Since nitrogens are used in making proteins, they are essential to plant growth and health. Plants such as tomatoes and corn, which do not have nitrogen-fixing bacteria on their roots, cannot grow well in nitrogen-poor soils. Legumes, however, can. Ask the children why clover, soybeans, and alfalfa are often used in crop rotation. The children may be able to guess that these plants replace nitrogen taken from the soil by other kinds of plants.

Legumes are not born, so to speak, with bacteria in their roots. Bacteria in the soil enter the roots of a young plant and migrate through the root hairs into the cortex of the root (area responsible for growth in width). Their presence here stimulates the area to grow the nodules, structures in which the bacteria thrive. Thus two kinds of plants, legumes and bacteria, live in a relationship of more or less mutual benefit.

The children can study the benefits of hosting nitrogen-fixing bacteria by growing clover or winter peas in the classroom. Have the children sterilize four clay pots in an oven and fill them with soil. In these pots they will raise clover (or winter peas) from seeds. When buying the seeds, ask whether or not the seeds have been inoculated with nitrogen-fixing bacteria. (Many legume seeds are commercially inoculated, for obvious reasons.) If possible, buy both inoculated and noninoculated seeds. The children should plant inoculated seeds in two pots; these will be used to test one hypothesis—nitrogen-fixing bacteria help their leguminous hosts thrive. In the other two pots, the control, the children may plant the noninoculated seeds. The plants should be kept in sunlight and watered regularly. The differences in growth will be obvious within a few weeks. The children may then uproot both the experimental and control plants and examine their roots.

If only noninoculated seeds are available, remove several nodules from an adult plant, crush them, and mix the crushed nodules with the soil in the experimental pots. Make sure the children take the nodules from an adult of the same species as their seeds. Explain that specific strains of nitrogen-fixing bacteria live on specific kinds of legumes. If the children put bacteria that prefer soybeans with winter peas, the bacteria may not invade the roots and the experiment would be invalid.

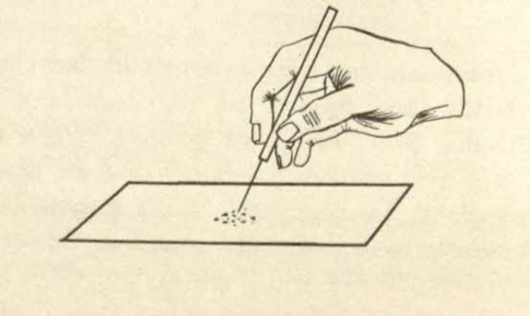
Learnings: (z) Some living things are parasites on others; they obtain food and shelter at the expense of the host. Other kinds of plants and animals live symbiotically; their relationships are mutually beneficial.

Additional Activities: If a high-power microscope is available, the children may make microscope studies of nodules and their contents. Cut off several nodules with a razor blade and distribute them to the children. Show the children how to crush a nodule between two microscope slides. Then add a drop of water to the bottom slide and show the children how to tease the nodule apart with a dissecting needle. Remind them that a specimen must be very thin to be observed under the microscope. Cover the teased specimen with a cover slip, and have the children examine the contents under both low and high powers of a microscope.

For better viewing, the slides may be stained with methylene blue. Place a drop on each of several slides. Allow the stain to dry. Then with a medicine dropper pick up a drop of water containing the contents of a teased nodule and place it on the stain. Prepare several slides in this way and cover them with cover slips. The children may look at the slides under the high power of a microscope. As the stain gradually diffuses into the water, the nucleus and granules in the cytoplasm of the bacteria will stain dark blue.

Children who show avid interest in the various kinds of interdependency can create conditions in which the normally helpful nitrogen-fixing

To view the bacteria in clover root-nodules, crush the nodules between two slides, add a drop of water and tease the pieces apart. Stain will make the bacteria more prominent on the slide and easier to see.



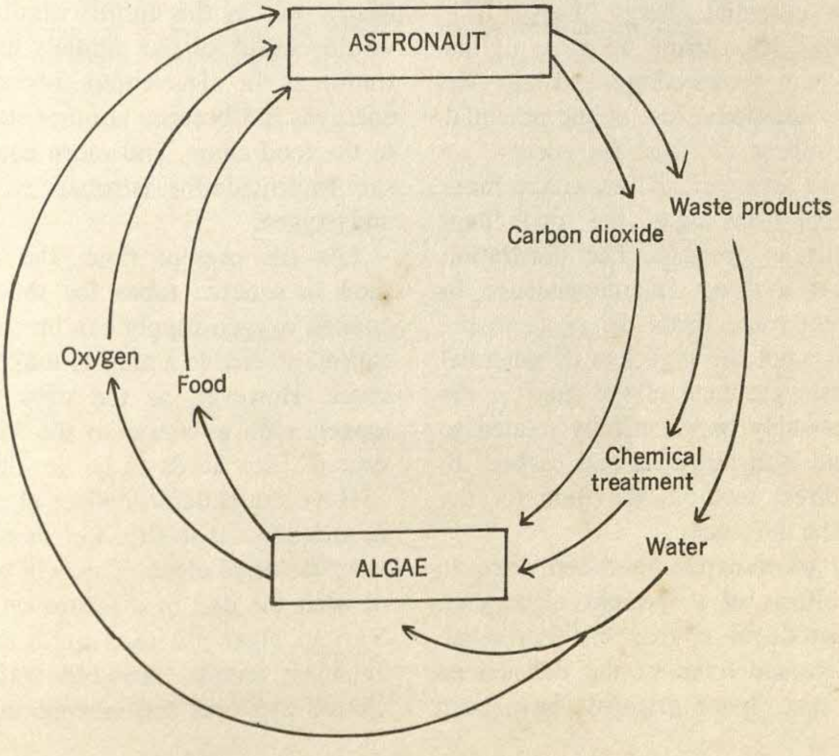
bacteria become harmful. For this experiment, the children will need expert help, perhaps from their local agricultural station or 4-H Club. With the help of the station or club, the children should obtain some soil deficient in boron, a trace mineral vital to plant growth. The children may try growing clover from seed in four pots of boron-poor soil. To two of the pots they should add nitrogen-fixing bacteria; the other two pots are the controls. The experiment, if successful, should indicate that in soils deficient in boron, the bacteria cease to fix nitrogen and become parasites on the clover, eventually destroying it. This experiment may be used to illustrate how environmental conditions help determine the relationships of living things to one another.

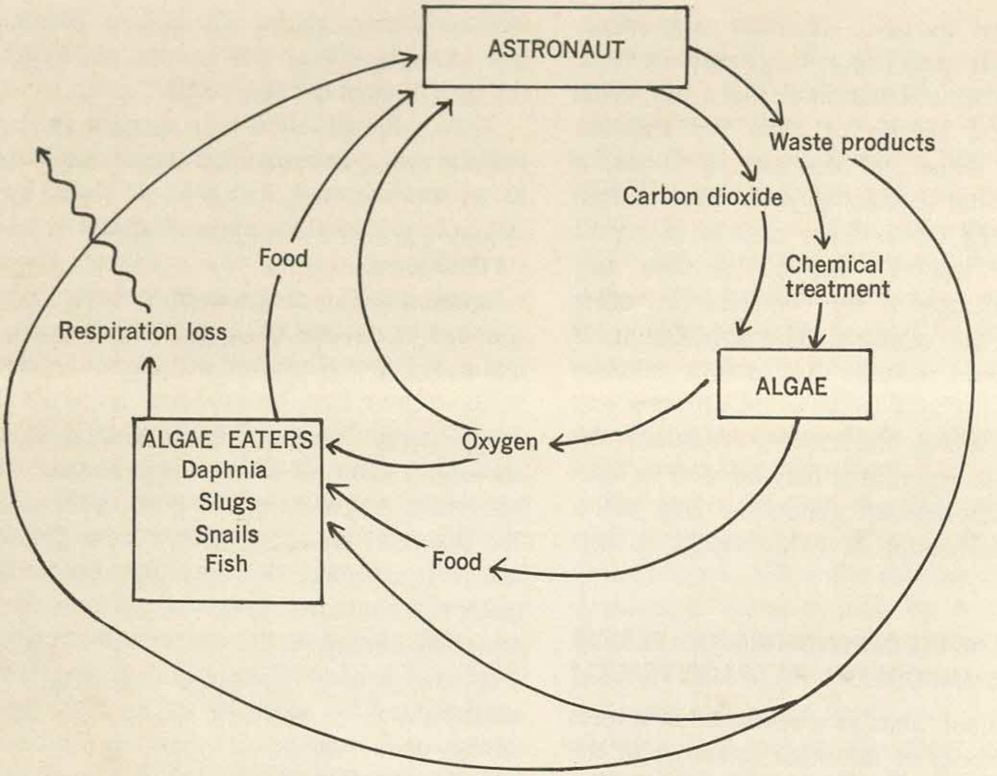
HOW IS THE INTERDEPENDENCE OF PLANTS AND ANIMALS IMPORTANT IN SPACE TRAVEL?

Man is an animal, and, as a result, he is subject to all of the needs of the other members of the animal kingdom. On earth, plants provide man with the oxygen necessary for life; and, in turn, man exhales carbon dioxide, which is used in the process of photosynthesis by the plants. The natural environment provides man with the necessary food and water and proper temperature for him to exist. Shelters devised by man have helped overcome some of the discomforts of temperature changes. Thus, man has the ability to alter the environment to fit his needs.

This is the situation with man in space. The normal space environment cannot maintain life as we know it, and, therefore, a "closed system" has to be prepared for a space capsule or a colony on the Moon.

Space scientists are concerned with a food chain that can be devised to support life in space. Food chains are of vital concern to the space researchers. A food chain may be explained as follows: The food energy from a plant source is expended through a series of living things as they eat and are eaten. At each transfer point, a large part of the potential energy available from the food is lost as heat energy. For example: Potential food energy is contained in an ear of corn. In order to satisfy energy needs, a steer will eat the corn. The steer expends energy maintaining his body temperature, so some of the original potential energy of the ear of corn has been lost through this first transfer. Man likes beef and eats the steer to satisfy his energy needs. Additional potential energy is lost through this transfer. Man must maintain his body heat, and, therefore, energy is lost through respiration. Other potential energy is lost through waste materials that eventually return to the earth, starting the cycle over





again. This is a three-step food chain, and there is a loss of energy at each stage. Additional energy is lost in a five-step food chain. For example: Green algae are growing in a body of water. Mayflies eat the algae, causing a loss of the potential energy of the algae. Small fish then feed on the mayflies, causing a further reduction in the available potential energy. Larger fish eat the smaller fish, thus using up more of the energy. Finally man comes along and eats the fish; and there is additional loss of the potential energy as man utilizes the food for energy.

In order for an astronaut to obtain the maximum food energy from algae, the food chain must be as short as possible. The illustration above points out a direct interdependence in space. By a direct route, from the algae to the astronaut, there is not the high loss of potential energy. The waste products of the man in the capsule might possibly be chemically treated to provide the algae with nutrients and carbon dioxide. In this direct method, the food for the astronaut would be the algae.

A great deal of research has been done to determine the effects of a straight algae diet. However, this produces a very tasteless meal. In order to overcome some of the deficiencies of an all-algae diet, space scientists have been working with more complex food chains. Note the illustration. In this example, another step is being added to the food chain. The algae provide food for a simple form of life, such as water fleas, slugs, snails, or fish. The algae serve as a source of oxygen for the astronaut and also for the other animals in the spacecraft. Man's diet in this more complex system, then, would consist of the animals listed in the illustration as the algae-eaters. More of the potential energy is lost because another step is being added to the food chain, and more equipment is necessary to provide the astronaut with sufficient food and oxygen.

(At the present time, the astronauts carry food in squeeze tubes for short trips. A large enough oxygen supply can be stored in the space capsule to enable a man to make a short trip into space. However, as the trips take longer and longer, such as a trip to the Moon, the "closed system" idea needs to be developed.)

Have the children collect algae, strain it, heat it, and allow it to dry. Let members of the class taste the dried algae. This will give them an idea of what the diet of a future astronaut might be. Various algae are used quite extensively by the Japanese people. Seaweed wafers can be purchased at stores specializing in Japanese foods.

Perhaps there is one in your community. Have the children investigate this possibility.

Plants and animals are interdependent whether they are on Earth or several hundred miles above Earth in deep space. The needs of living things as we know them are no different in the two locations. Scientists are experimenting with ways of varying air pressure, with different foods, and with psychological effects on man for space exploration.

The food chain provides living things with the energy for life. Various food chains provide differing amounts of potential energy for consumption by man. The shorter the food chain, the greater the available amount of energy which can be converted to use by a living organism. The food chain of lower animals is generally much shorter than the food chain for man because the lower animals depend completely on the environment while man can alter the environment to suit his needs.

Over the years, living things have adapted to their environment in a variety of ways. Do you suppose it is possible for man to adapt to the very different conditions existing in space?*

---

* For activities and information on the interdependence of plants and animals in space travel, see *Space*, by Arthur Costa (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

IMPORTANT IDEAS IN THIS CHAPTER

For the kindergarten, primary, and intermediate grade children, the kinds of ideas with the most meaning and application are:

- Some animals and birds migrate as an adaptation for survival.
- Some animals adapt to seasonal changes by hibernating.
- An animal's coloration may be a means for its protection.
- Some animals can change their color to match that of their environment.
- Phototropism is the response that stems and leaves show toward light.
- Roots grow toward water.
- Water is absorbed by the root hairs.
- The flowering of many plants is determined by the amount of time the plant spends in light and darkness.
- Seasonal changes influence the growth of plants.

In the intermediate and upper grades, the children should be led to develop concepts that are more complex:

- Plants respond to the Earth's gravitational pull.
- Roots are positively geotropic.
- Stems are negatively geotropic.
- The greatest phototropic response is exhibited by the growing tip of a stem.
- Most insects undergo metamorphosis.
- Hydras reproduce both asexually and sexually.
- A parasite obtains food and shelter at the expense of the host.
- A symbiotic relationship is beneficial to everything that exists within it.

5

INVESTIGATING LIVING THINGS THROUGH FIELD TRIPS

A field trip must be well planned for it to be a valid educational experience, not just a romp. Students rarely make worthwhile observations or exciting discoveries without adequate preparation. They will be prepared to look for and recognize illustrations of the concepts being explored in class if they know what kinds of things to look for and where to look. As Pasteur said, "Chance favors the prepared mind."

You may need the help of other adults in conducting a field trip. Parents are willing to devote their time to explorations with their own and other children, whether it be a trip to a field, pond, zoo, botanical garden, or aquarium; but they do have to be asked. If they are adequately informed of what they are to do and given a few simple instructions on how to do it or, better, how to have the children do it, many parents are willing volunteers.

You will probably find it advisable to divide the students into groups and assign them to parents *before* the trip. Each group could have a tag of a different color, so that if a child has a momentary lapse in identifying his group, he can remember by the color of his tag. Colored tags also help parents take quick counts of heads. Parents cannot be expected to remember each child's name, but they can make a swift identification by the color of a tag. It is wise to keep a few extra tags on hand in case one parent is unable to go at the last moment and the students must be reassigned to other groups.

When requesting parents to sign the slips granting permission to take the students off school grounds, you might include a schedule of activities, stating the day and time of the trip, the departure point, length of time you expect to be gone, and, if necessary, when and where the students may be picked up after the trip (see sample schedule). If the trip requires that the student carry special equipment, this should also be noted. It would be helpful to parents, particularly those of young children, to state the kind of clothing most appropriate to the site, like jeans for walking through brush and galoshes for wet areas.

VISITING A BIOME

A biome is a community of living things that are dependent upon one another for survival. A biome may be studied in an open field, meadow, forest, pond, rapidly flowing stream, tidal pool, desert, or any other natural environment. By visiting relatively undisturbed locales, the students can see the kinds of mutual interdependence—both cooperative and competitive—that exist among living things. The experiences gained through visiting a biome may climax concepts learned in class or provide a basis for further work.

Selecting the Site

No matter where you live, there is a good biome near you. A good biome contains a variety of land forms and different kinds of plant cover.

The usual, and often the best, way to select a biome is to find the site yourself. This may require short excursions into the countryside, if you are not familiar with it. Your students may also have some suggestions. On outings with their parents, they may have come across open fields, glades, ponds, lakes, or other suitable places. Of course, you will have to check their suggestions.

When you select the place, find out if it is privately owned, for you should ask permission to use the site, particularly if you wish to remove specimens. Also check with your wildlife bureau for local conservation measures and for regulations against removing species protected by law.

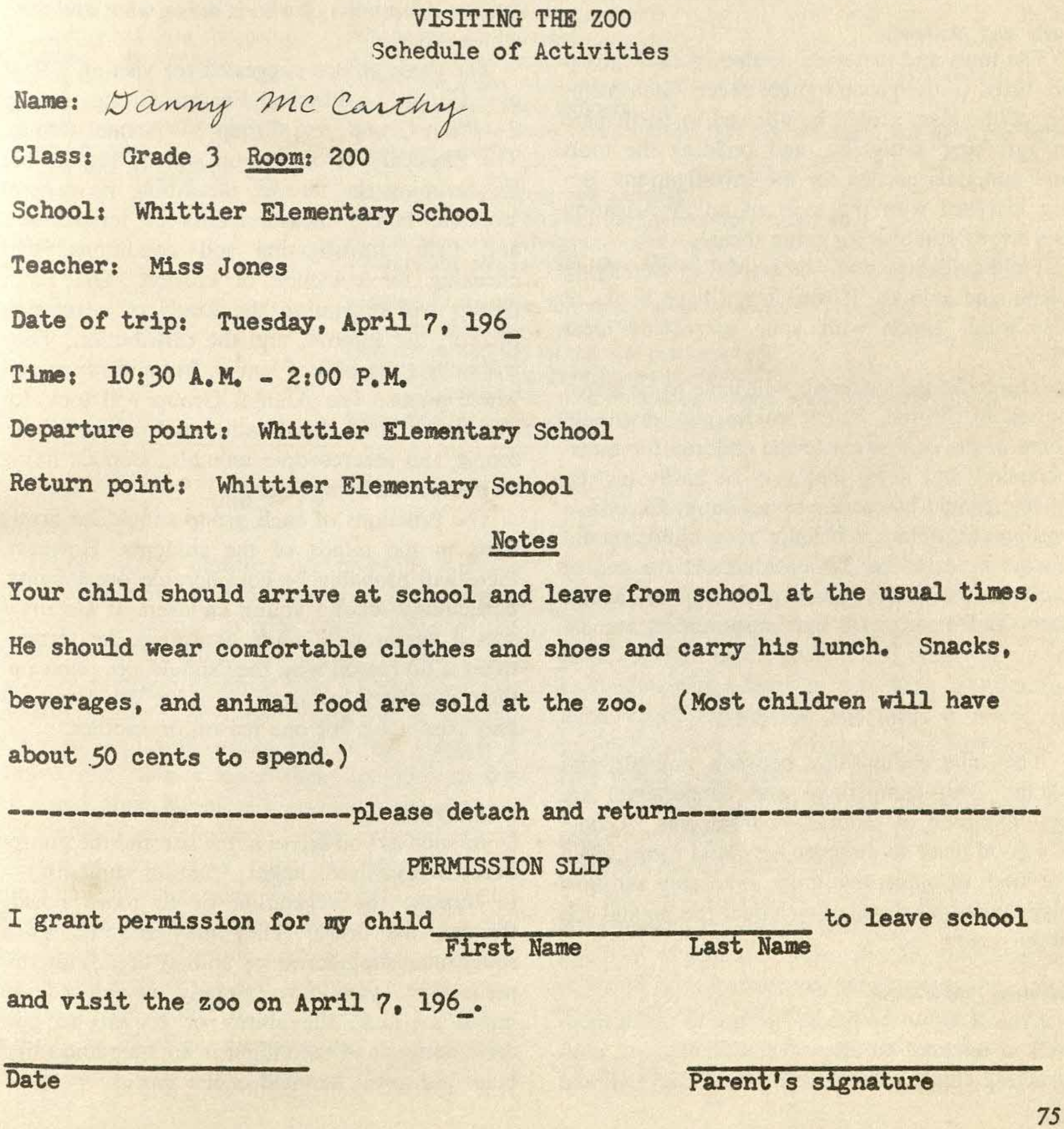
If you need more assistance in selecting your biome, perhaps your local conservation bureau can help. They frequently can tell you of areas where good biomes exist, and perhaps can steer you to projects they are involved in. If the latter is true, the bureau probably has a written and mapped history of the area and can lend you copies for classroom use. This material may be used to study ecological succession, or how a biome changes through the years.

When you have selected the site, make a clear map or notes on how to get there for distribution to other drivers transporting students.

If you cannot travel out of city limits, perhaps a park or a long-vacant lot may be explored. These places are more than adequate to observe the interdependence of living things. However, undisturbed areas outside the city are preferable. Parks are cut and trimmed and sprayed with insecticides, killing certain insects and driving away the animals that feed on them; and vacant lots have usually not been vacant long enough for a rich biome to have developed.

Preparing Your Guides

Your guides may be parents or students, depending on the age and ability level of the class.



VISITING THE ZOO
Schedule of Activities

Name: Danny MC Carthy

Class: Grade 3 Room: 200

School: Whittier Elementary School

Teacher: Miss Jones

Date of trip: Tuesday, April 7, 196_

Time: 10:30 A.M. - 2:00 P.M.

Departure point: Whittier Elementary School

Return point: Whittier Elementary School

Notes

Your child should arrive at school and leave from school at the usual times. He should wear comfortable clothes and shoes and carry his lunch. Snacks, beverages, and animal food are sold at the zoo. (Most children will have about 50 cents to spend.)

-------------------------please detach and return-------------------------

PERMISSION SLIP

I grant permission for my child________________________ to leave school
First Name Last Name

and visit the zoo on April 7, 196_.

____
Date

____
Parent's signature

At least one guide should carry a first-aid kit. All guides should be able to recognize any poisonous plants, such as poison ivy and toadstools, and poisonous snakes, if there are any in your area. If equipment is to be distributed to guides, they should have a list of it and how it should be used. If parents are to participate in gathering equipment, they should be given adequate time to do so. Guides should also see that the site is as clean when you leave it as it was when you found it. The cleanup detail should involve the whole class.

Each guide should have a copy of the student guide sheet directed toward his group.

Tools and Materials

The tools and materials needed by each group are listed in the group's guide sheet. Each member of the class should be allowed to participate in gathering, designing, and building the tools and materials needed for the investigations. Being involved with the tools of an investigation is a strong stimulus for using them.

Field guidebooks will be helpful in identifying plants and animals. If you do not have books of this kind, check with your school or local library.

The tools and materials will have to be transported to the site. Parent guides may distribute some of the equipment to the children for transportation, but items that may be easily broken or lost should be carried by an adult. Expensive equipment, unless it belongs to a child, should always be cared for by an adult. At the end of the trip, the guides should gather up the equipment and arrange for its transportation home.

VISITING A FIELD

The interrelationships between animals and plants, both competitive and cooperative, are best explored in natural environments. A field is a good place to discover how land forms affect the kinds of plants that grow in an area and how plant type and distribution affect the animal life of the region.

Advance Preparation

If tools are to be made, be sure to make them well in advance to allow for difficulties in constructing them and to insure that they will be ready on time. The finished tools may be displayed around the classroom for motivation.

Guide sheets for each group should be prepared, duplicated, and distributed to each child or parent guide. These sheets may consist of questions to be investigated on the site. Go over the sheets in class and relate the questions to previous Activities and those you will do in the future. By discussing the guide sheets, the students will have an idea of what they will be looking for in the field. Find out which children have definite preferences or inclinations toward doing a specific thing, and then divide the children into groups and assign them to guides. Keep a list of who is doing what and with which group.

The three groups suggested for visiting a field are: Group 1—Physical Factors Group; Group 2—Plant Group; and Group 3—Animal Group. The Physical Factors Group will be responsible for mapping the terrain, describing its general features, taking measurements of temperature and light, investigating soil conditions, and checking for evidence of erosion. The Plant Group will determine the kinds of vegetation present, the amount, and the distribution. They will collect samples of leaves, fruits, flowers, and whole plants. The Animal Group will look for evidence of animal habitation and collect microscopic and macroscopic animals, animals living on plants, and flying insects.

The functions of each group should be firmly fixed in the minds of the students. However, there will probably be considerable overlapping, particularly among young children. If Group 1 sees a spider web while exploring the terrain, there is no reason why they should not point out their discovery to Group 3. After all, Group 3 may pass it by, for one reason or another.

At the Field

As soon as you arrive at the site and the groups become organized, begin. Caution students not to trample the vegetation or to move noisily through the brush. They may frighten away some interesting forms of animal life. With this precaution, you have already introduced an important idea: the ability of animals to perceive danger and take flight is an adaptation that helps insure the survival of the species.

VISITING A FIELD

Guide Sheet

Group 1—Physical Factors Group

Materials needed:

Thermometers for measuring temperatures
Yardsticks for measuring distance
Light meter for measuring light
Magnetic compass for finding direction
Large sheet of paper, supported on a board, for map of land profile
2 quart glass jars for collecting soil samples
Pencils
Grease pencil to mark jars
Watering can and water (if none on site)
Trowels for digging up soil samples
Stop watch
Stakes
Hammer
String (100 yds.)
Camera

Activity 1—Describing the general terrain
What does this area look like?
Where are there trees?
Where are there bushes?
Where are there herbaceous plants?
Where is there ground cover?
Where is there water?
What prominent land features, such as boulders, are there?
How can they be marked on a map?
How can a land profile be made?

Activity 2—Measuring temperature and light
Which areas get the most sunlight?
Which areas get the least sunlight?
What are the temperatures in these areas?
What is the relationship between light and temperature?
How may plants affect temperature?
Why may temperature vary in areas that are far apart but have the same ground cover?

Activity 3—Collecting soil samples
What relationships do you notice between plants and soil?
How do soils with different kinds of vegetation compare?
When taking soil samples, why should you put each sample in a separate jar?

Activity 4—Looking for examples of erosion
Where are there bare patches of soil?
How do you account for the bare patches of soil?
How do you think plants help prevent erosion?
How can we test which kind of plant cover helps prevent erosion?
Where does soil washed away by rainfall go?

GROUP 1

Activity 1

Primary-grade children are probably capable only of walking around an area and making simple observations to help answer some of the questions on the guide sheet. Intermediate-grade and upper-grade children may choose to make measurements. They may mark off a specific piece of land with stakes and string. Groups 2 and 3 may then confine their activities to the enclosed area. By closely confining the area to be studied, students may draw more accurate inferences. You may point out that scientists limit their investigations. For example, a scientist would not study all the animals in a field. He would choose a specific area and then look for a certain kind of animal, perhaps microscopic, within it. He would then correlate his findings with those of other scientists, and together they would draw inferences based on their work.

Once the area has been roughly explored (and measured), draw a map. Using a magnetic compass, the children can find north and draw an arrow showing the direction of north. If they do not have a compass, they can stick a tall pencil upright in the ground and mark the tip of its shadow with a small pebble. After 20 minutes, again check the shadow and place a pebble at its tip. By drawing an imaginary line between the two points, you have the path of the sun, or east–west. At right angles to this line will be north and south. Mark the orientation on the map, and draw a land profile.

Then students should draw on their map and land profile the major land features and the kinds of vegetation. They should note sources of water, rock formations, bare patches, etc., and distinguish trees, shrubs, and nonwoody plants, such as grasses, certain flowering plants, and weeds. They should also indicate floor covering,

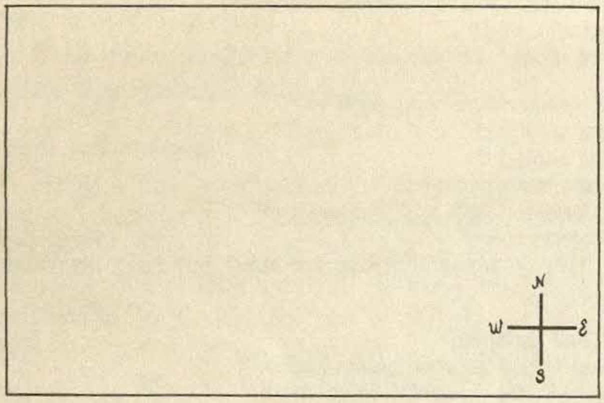
MAKING A LAND MAP AND A LAND PROFILE

Symbols

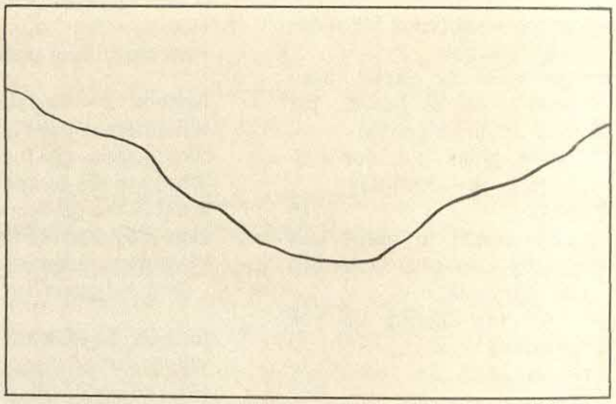
△	Trees	⌂	Grasses and small plants	∼∼∼	Sparse vegetation	⬭	Pond
♀	Bushes	▬	Soil litter	× × ×	Large rocks or rock areas	≈	Stream

MAP

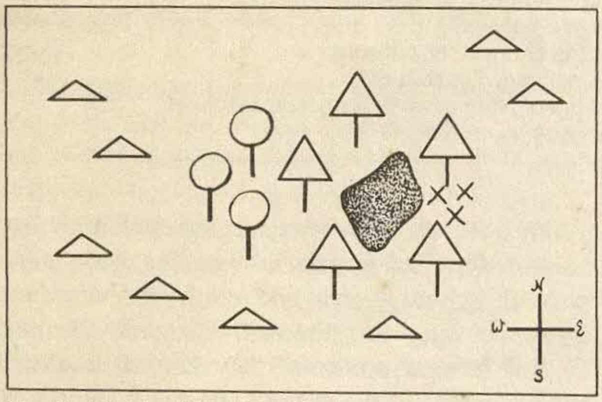
PROFILE



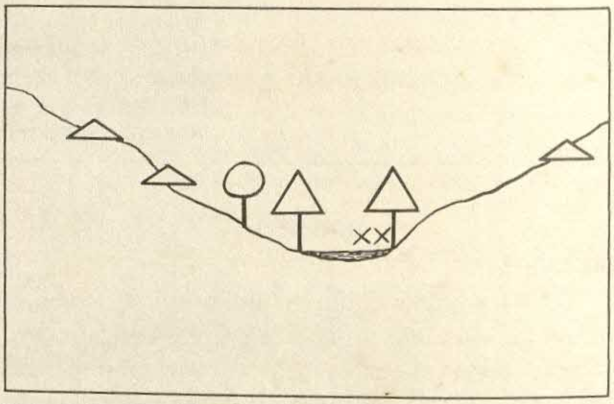
Step 1. Orienting the Map



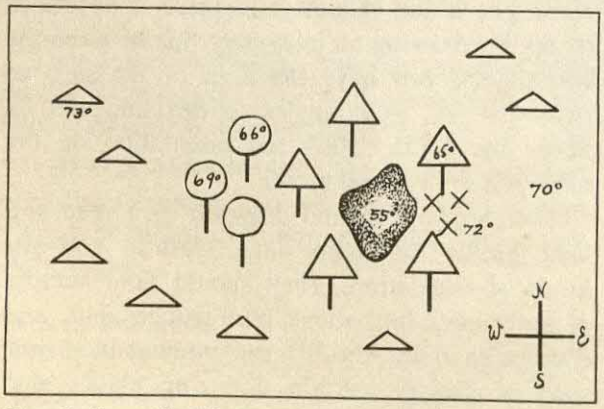
Step 1. Drawing the Profile



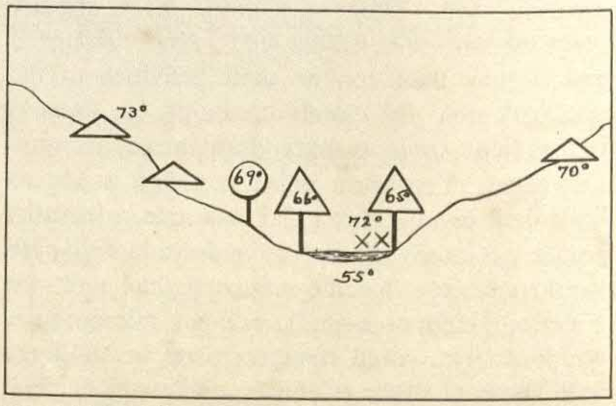
Step 2. Marking Plant Distribution



Step 2. Marking Plant Distribution

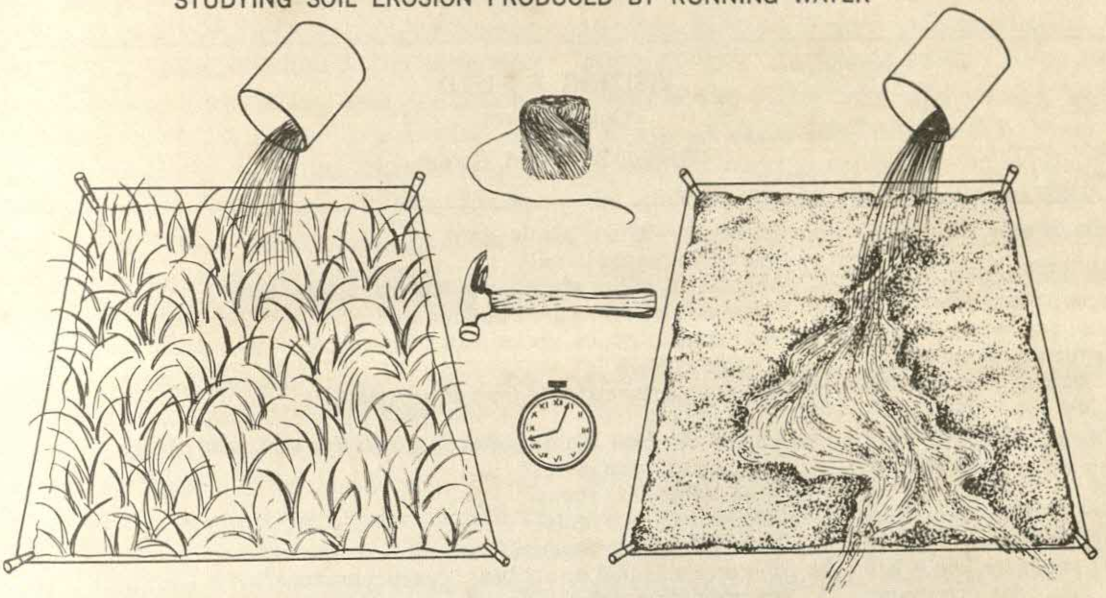


Step 3. Recording Temperatures



Step 3. Recording Temperatures

STUDYING SOIL EROSION PRODUCED BY RUNNING WATER



Grassy area

Bare area

which includes fallen leaves and plant debris and small plants like mosses and liverworts. With a camera they may now photograph the features of the area, such as gullies, plant covering, rock formations, and slopes. These photographs can be used as the basis for showing seasonal changes if compared with photographs taken of the same places at different times of the year.

Activity 2

The group may now take temperatures and light-meter readings near the features they marked on the map. The purpose of this is to note the relationships between light, temperature, and plant growth. Thermometers should be placed in the open, under and near bushes and trees, and on slopes, if present. Students may be puzzled why a temperature reading taken in one place varies from that taken in another place with the same kind of vegetation. Ask them to relate their observations to the amount of sunlight each place is receiving.

Activity 3

In addition to light and temperature, what else may affect plant growth? Students should take soil samples from different areas. Be sure to include soil from bare areas, damp spots, under trees, in the open, etc. Dig up a sample about the shape of the trowel from each area. Be sure to label the jar with the location of the sample and the kind of plant covering it had. Upon returning to class, the students may test the soil samples for acid content, compactness, and ability to hold water. What conclusions can the students draw from their tests?

Activity 4

If there are slopes with varying kinds of vegetation, students may investigate how plants help prevent soil erosion. On the slope, mark off with stakes and string several areas measuring about 1 yard square. Be sure to include one bare area, one with a bush, one with rocks, and one covered with grass. Then as one student pours water at the top of the marked area, another can note soil runoff and observe the time it takes the water to pour down the slope. Students should realize that they are simulating rainfall and that rain washes away large amounts of soil from bare ground. When the kind of soil that supports plant growth is removed, plants can no longer grow, and the animals that depend on the plants for food and housing either die or move elsewhere.

Follow Up

When the groups return to class, they should report their experiences and correlate their findings.*

---

* For further activities and information in the field of earth science, including soil, rocks and minerals, and erosion, see *The Earth,* by Lawrence Hubbell (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

VISITING A FIELD
Guide Sheet
Group 2—Plant Group

Materials needed:

- Scissors for cutting
- Wax paper, newspapers, and books or heavy boards for pressing flowers
- Cigar boxes for storing specimens
- Masking tape for labels
- Burlap for transporting ferns
- Jars for mushrooms, lichens, and mosses
- Blotting paper for lining jars
- Hand lens for observing lichens
- Knife for cutting moss and bark
- Hammer and chisel for chipping rocks bearing lichens
- Camera

Activity 1—Where plants grow

Do all plants grow in soil?
What do you notice about the plants that grow in soil?
Where else do plants grow besides soil?
What do you notice about plants growing on trees, rocks, and decayed organic matter?
How are plants related to their environments?

Activity 2—How plants differ in structure, size, and color

Do all plants have leaves?
Do all plants have stems?
Do all plants have roots?
Which plants bear flowers?
How do plants that do not bear flowers reproduce?
How do flowers differ in size, shape, and scent?
How do leaves differ in size, shape, arrangement on the branches, location on the plant?
How do roots differ?
How do root structures help the plant adapt to its environment?
How does the size of a stem relate to the size of the plant?
How can you tell which plants are older?

Activity 3—Dominant plants of the area

Which plants seem to dominate the area?
How do you account for the dominance of some plants?
Which plants seem to be reproducing faster?
How can you tell which plants are reproducing faster?
Which plants are less abundant?
Why are some plants less abundant?
If there were no changes in climate and the site were left relatively undisturbed, what do you think the site would look like 100 years from now? Why?
Under the same conditions what do you think the site would look like 1,000 years from now? Why?

GROUP 2

The students should follow their guide sheets and answer the questions by doing the following Activities. The Activities may be done in sequence or simultaneously. Photographs of the group in action and of the various specimens studied will help students recall their experiences.

Activity 1

The students should realize that there are numerous kinds of plant life, adapted to living in a wide range of places. Most children think of plants in terms of trees, bushes, and grass, all of which grow in sunlight in soil. This Activity should develop an awareness of the variety in the plant kingdom and the factors that influence this variety.

Have the children notice that soils differ and that the plants growing in them differ. Compare the plants growing in rich humus with those growing in sandy spots. Notice that some kinds of plants are growing in very moist ground while others are thriving in what appears to be almost bone-dry soil. When they have observed that soils differ and that the plants growing in them differ, ask the students where else plants may grow. Have them look among the branches of trees and bushes, on the sides of trees, in soil litter, and on rocks. Look at decayed stumps and trunks. The children should find nongreen plants, including mushrooms and toadstools. These plants, which are called saprophytes, do not manufacture their own food; they obtain it from dead or decaying organic matter. Relate this idea with where saprophytes are found. Now look for parasites, like mistletoe, which lives in the branches of trees, sends its roots into the living tissues of the trees, and removes water containing dissolved nutrients (sap). Look on rocks for lichens, small "plants" that are actually composed of two kinds of plants that help each other (symbiosis). One, a fungus, obtains and holds water, anchors the entire structure, and holds the other, an alga, up to sunlight. The alga makes food for both of them. Look at the lichens through a hand lens and you should be able to distinguish the white fungus from the greenish alga.

Examine rocks, tree trunks, and soil for the small green plants known as mosses. Along the banks of streams or in moist ground, look for liverworts, tiny flat green relatives of the mosses. After they have observed the plants in their various sites, the children are ready for the next Activity.

Activity 2

Students will probably have found lichens, mosses, fungi, ferns, and other plants that reproduce sexually, such as trees, grasses, and bushes. Starting with the most familiar, the vascular plants that reproduce sexually, note their similarities and differences. This group has roots, stems, and leaves, and bears flowers. If your visit is in the spring, compare the various kinds of flowers. Some plants bear numerous flowers, others only a few. Some flowers smell sweet, others have no scent or give off a distasteful odor. The children can easily determine this by smelling a few blossoms. Before smelling sweet-scented flowers, they should be sure that no bees or other insects are present, for plants that rely on insects to carry pollen produce sweet scents and nectar to attract them. The children can also taste the nectar by pulling a few blossoms from their receptacles and sucking on the ends. The children snould note which flowers are open, with exposed stamens and pistils, and which have their stamens and pistils enclosed by petals or bracts. Older children who are familiar with the structure of flowers can also examine the separate male and female flowers borne by such plants as the willow, oak, and walnut, and look for species like the holly, which bears male flowers on one tree and female on another. Have the children suggest theories as to how these plants are fertilized. *(Pollen is carried by the wind, or by insects traveling from one plant to another.)*

For later study in class, students may clip, near the base of the stem, a few specimens of each type of flower. Carefully arrange each flower on wax paper, fold the paper over, and press the flower by inserting it between the pages of a book. Before you go on your trip, find out which flowers may be picked and which ones should not be touched. Have the children speculate as to why certain species should not be picked.

If your trip is in the autumn, notice the variety of fruits. A fruit, as the botanist defines it, is a matured ovary. Fruits include nuts, tomatoes, dandelion "seeds," pods, smooth capsules, burs, and, of course, the familiar sweet pulpy variety like an apple. The children should relate how the kind of fruit helps determine how the seeds are spread. Sweet fruits are carried away by birds and other animals, which eat the pulp and leave the seeds in the new site. Capsules become dry and burst open. Some capsules, like milkweed, have long fibers that are easily carried by wind. Burs catch in the coats of animals and are carried long distances. Children may collect fruits (perhaps getting burs by removing them from their clothes) and carefully label them with the name of the plant from which they come. Use masking tape to label succulent fruits and to wrap around the stems of capsules and burs. Store the fruits in cigar boxes.

STATE INSTITUTE OF EDUCATION
Govt. of West Bengal

The group should then compare the numerous kinds of leaves, including blades of grass and simple and compound leaves from trees, bushes, and "weeds." They may collect the leaves by picking samples off the ground or by clipping them from the plants. Note the name of the plant, and press the leaves in the same way in which the flowers were pressed.

Compare the stems of herbaceous and woody plants by having the children note the color and texture of the stems. To emphasize that woody stems provide greater support, have children bend both kinds of stems. (Do not bend woody stems until they snap.) Note the relationship between the thickness of the stem and the height of the plant. Tell children that we can tell the age of a tree by looking at a cross section of its trunk. If there is a tree stump in the area, call the children's attention to the annual rings and count them to determine the stump's age.

Ask the children what they think the roots do for a plant. *(Roots anchor a plant in the ground, and water and dissolved minerals enter roots and are conducted up stems to leaves.)* The children may find that plants in protected areas near water are more loosely anchored than plants in dry, exposed areas. To demonstrate this, have a child grasp, at its base, a small nonwoody plant growing near the water. Have him pull it up, roots and all. Then have another child try to pull up a plant growing in a dry area. He may be able to pull out a few roots. Observe the roots of both plants, and compare them as to length, abundance, and distribution. The students should come to the conclusion that in dry, windy areas roots are numerous and grow deep in the soil. This helps anchor the plant and enables it to reach water that is deep in the soil. The students should be able to deduce why plants that grow in protected areas near water generally do not thrive in dry, exposed areas.

Carefully examine a fern. You may have to unroll some of the young leaves. Study their structure, and have the children examine the more mature unrolled leaves. They should find spore cases on the underside of the leaf. The children should be led into a discussion of the function of the spore cases. Clip several fern branches and lay them between sheets of moistened newspaper. (Dry newspaper may cause capsules to ripen and burst open.) Older students familiar with alternation of generations may search for prothallia. To transport ferns back to school, dig up the rhizomes (mass of roots) together with plenty of soil. Wrap the entire plant in damp burlap, taking care not to break small roots.

Look for evidences of fungi. If there are mushrooms, carefully dig up several with soil around their bases. Gently shake the soil away from the base of one or two, and have children note the mass of threadlike structures. This is the mycelium; it absorbs food and water. The "stems" and caps are the reproductive organs. You may take several mushrooms back to class in jars to make spore prints. Keep them moist, cool, and out of light. If a bracket fungus is growing on a rotting stump, cut off a piece of the stump and take it with you. *(Caution: Warn children not to touch toadstools, which are poisonous. If a few spores stick to their hands and they put their hands in their mouths, illness may result.)*

The children may also take small rocks bearing lichens and mosses back to class by putting the rocks into jars containing moistened blotting paper. If the rocks are too large for easy transport, chip off a piece with a rock-collector's or mason's hammer and chisel. Mosses growing on trees may be cut off, taking care to remove the bark on which they are growing. (*Caution:* Do not cut large strips of bark from around a tree. Girdling a tree, or cutting off a belt of bark, kills a tree because the phloem tissues, which transport water and dissolved minerals, lie just under the bark.)

Activity 3

A biome is always in a state of transition, although the change may occur over hundreds of years. Children may be able to predict the kinds of changes that will occur by observing which plants are thriving and seem to be reproducing most rapidly. Have the children note the number and kinds of trees and count the number of seedlings of these species, noting where they are located. Relate what they know about plants that thrive in shade with the fact that these trees, when adult, will produce shade. Discuss what will happen to sun-loving plants when these trees grow. Relate this to the types of flowers found in the spring before the leaves of the trees appear. Point out that soil builds up as new dead organic matter is deposited, causing changes in the features of the land. Have the children guess what they think the site may look like one hundred years from now, giving reasons for their guesses.

Follow Up

In class, students may mount and label their cut specimens for display and use whole plants to make terrariums. They should compare their observations with those of Groups 1 and 3.

VISITING A FIELD

Guide Sheet

Group 3—Animal Group

Materials needed:

- Camera
- Forceps or tweezers for handling small specimens
- Plaster of paris and a canteen of water for making casts
- Spoons and a shovel for digging
- Tin cans for catching specimens
- Gallon jars with punched lids for housing specimens
- Cheesecloth for covering jars
- Grease pencils for labeling bottles
- 70% ethyl alcohol for preserving jars
- Rubber bands, cotton, cork disk, carbon tetrachloride **(Caution. Be careful of noxious fumes.)** for killing jars
- Hand lenses
- Nets for catching flying insects and other animals
- Scissors for clipping plants
- Old Sheet
- Chloroform **(Caution. Poisonous and explosive, should be handled by an adult.)** for drugging insects
- Large kitchen strainers for catching reptiles and amphibians.

Activity 1—Looking for evidence of animals

Where do animals make their homes?
How can we locate animals' homes?
What are some signs of animal inhabitation?
How can we find ants?
How can we tell if herbivorous animals have visited the site?
Where do we look for animal tracks?
What can we tell by animal tracks?
How does the evidence indicate that animals are dependent upon plants and other factors in their environments?

Activity 2—Kinds of animals that live in the soil

How do animals that live in soil litter differ from those that live underground?
How many stages of animal life are present in the soil?
What kinds of animals burrow and make tunnels?
How does the temperature on the surface of the soil differ from the temperature at different levels in the soil?
How does the temperature difference influence the animals that live on, and in, the soil?
How does the pressure vary under the surface?
How are animals adapted to living in the soil?
How do worms and other tunneling animals help plants?

Activity 3—Kinds of animals that live on plants

Where do we look for animals that live on plants?
During how many stages of animal life can animals live on plants?
How are animals that live on plants different from those that do not?
What are the animals living on the plants?
What kinds of flying insects live on plants?
In what ways are the animals that live on plants alike?
How do the animals that live on plants differ?
What kinds of animals live under logs?
What kinds of animals live under rocks?
Why should we return to their original positions logs and rocks that we have rolled over?

GROUP 3

The students should follow their guide sheets and answer the questions by doing the following Activities. Activity 1 should be done first; Activities 2 and 3 may then be done either in sequence or simultaneously.

Activity 1

The entire class should participate in the first part of this Activity. As soon as the class arrives at the site, all students should spread out in a large circle, locate themselves under trees, in grass, near logs, etc., and stand there *quietly*. They should scan the site, looking for movements in the treetops and grass and listening for the snapping of twigs, the rustling of leaves, and other sounds. During this quiet period, larger species not frightened out of the area by the noise of the class's arrival may venture out to survey what the disturbance was about. Squirrels and ground animals may peer out of their retreats, and birds may alight on the ground in plain view and begin feeding. As soon as a member of the class sees an animal, he should slowly and quietly raise his hand and point to it. Other members should be alert to what their classmates are doing and follow with their eyes where their classmates are pointing. After about 5 minutes of observing where the animals are and what they are doing, the class may break into its groups and begin the Activities. In dispersing, all groups should be careful not to thrash around in the grass and bushes, for this will scare away many of the insects and other animals.

Group 3 may continue this first Activity by observing and recording with a camera more evidence of animal inhabitation. The students should scan the ground for ant mounds or for a "fairy ring," a distinct belt of vegetation that often encircles a nest of harvester ants. They should look for cropped grass, a sign that the site is visited by deer and other herbivorous mammals, and for young trees stripped of bark, a favorite food of beavers and other large rodents. Nutshells around the base of a tree may indicate a squirrel's nest high in the trunk. The students should also scan the ground for dead insects and animal debris, including droppings, shed cocoons, and ant wings (in the spring). Since the children will probably not be able to identify some of the things they find, they may pick them up with their hands or with tweezers and put them in boxes for transport back to school for further study and identification.

The children should also look for tracks in soft ground. By examining the kind of print (hoof or toes) and its depth, the children may speculate about the kind of animal that left the track. By measuring the space between prints, they may be able to determine whether it was walking or running. If the tracks are fairly deep and well defined, as fresh tracks in mud often are, the children can make a plaster of paris cast of the prints. To make a plaster cast, add water to plaster of paris until the mixture has the consistency of loose batter and is just thin enough to pour. Gently pour plaster into the tracks. After about 30 minutes the plaster will be dry, and the cast may be lifted. Back in class, the students may compare their cast with the illustrations in reference books to verify their guesses about the kind of animal that made the tracks.

The children should also look on the ground for burrows, up in trees for bird's nests, and among the branches of bushes and trees and in the grass for spider webs and caterpillar cocoons. From these evident signs of animal inhabitation, the students should deduce how the animals that left the evidence are dependent upon the area for food and shelter.

Activity 2

After children have made broad observations of the area, they should begin more intensive investigations. Choose an area where there is a thick layer of soil litter, and carefully remove the dead leaves and other decaying matter, layer by layer. Notice which animals are near the top and which are burrowing through the litter. Using spoons, the students can scoop these species into tin cans and transfer them to a large jar containing some soil litter. The jar should be marked with a grease pencil or a felt-tip marker, indicating the kind of site where the species were found.

Then dig down into the ground with a shovel. In the upturned soil and along the sides of the hole, look for adult animals, pupae, larvae, egg sacs, and burrows and tunnels. When the hole is about 12 inches deep, have the students roughly compare the temperature and dampness of the surface of the soil with that at the bottom of the hole by feeling the soil with the backs of their hands. Point out that worms, larvae, and incubating eggs need moisture and that exposure to light causes them to dry out. Also relate the presence of worm and ant tunnels to the idea that plant roots and worms, beetles, ants, and other animals living underground need air.

By the following simple method, compare the pressure at the surface of the ground with the pressure underground. Have several students extend both hands. In one hand put a large handful of dirt; leave the other hand empty. The children will immediately be aware that dirt weighs more than air and should be able to relate this idea to the fact that pressure is greater underground than on the surface. The children may then discuss how the hard exoskeletons of some kinds of insects serve as protection against external pressure and how tunneling helps relieve the pressure on both soil-dwelling animals and plant roots.

If the students spot an ant mound, they may want to dig into it and take some ants back to the classroom for an ant farm. To obtain the ants, insert a shovel about 6 inches from the entrance to the nest and push it deep, pointing toward the entrance. You will probably expose some of the incubating chambers. Scratch through the nest and the clod or shovelful of dirt to get grubs (larvae), cocoons (pupae), and plenty of workers. Try to capture one or more queen ants, which can be distinguished by their large size. Put your captives in a jar containing soil from the nest, stretch a piece of cheesecloth across the mouth, and seal the jar with its lid.

Captured species, whether ants, grubs, or beetles, should be placed in bottles marked with the type of location in which the animal was found. If you prefer to kill and preserve the specimens, drop soft-bodied forms, like worms and larvae, into a container of 70% ethyl alcohol. Hard-bodied insects, such as beetles, may be placed in killing jars.

To make a killing jar, pack rubber bands into the bottom of a jar and soak them with carbon tetrachloride. (Carbona and other spot removers are composed of carbon tetrachloride. *Caution: Do not sniff this chemical; its fumes are noxious.*) Pack absorbent cotton over the soaked rubber bands, and over the cotton lay a disk of cork, perhaps cut from an old table mat. You may use jars of different sizes, and all jars, of course, should have tight lids.

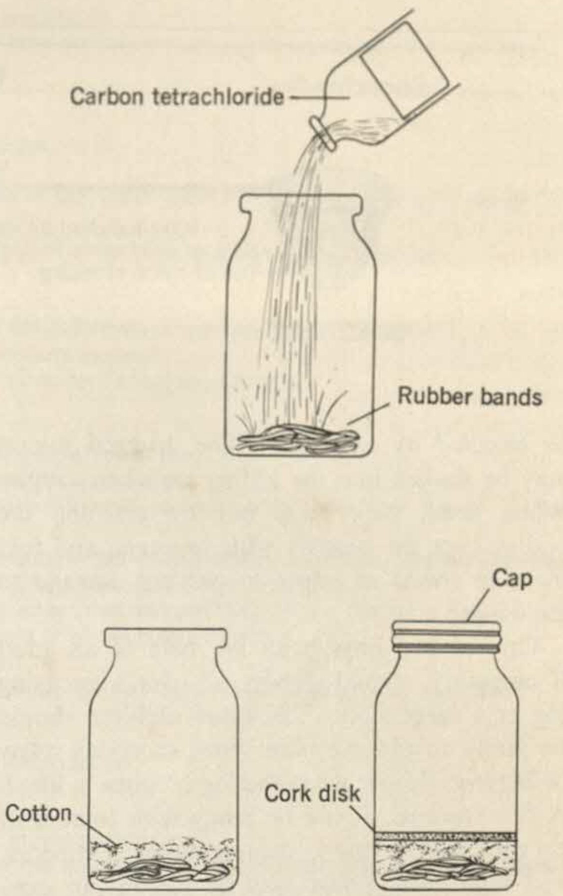
Activity 3

Look for evidence of animals living on plants. Many animals live only on plants, and by examining the undersides of leaves, the notches between leaves and stems, flowers, fruits, and buds, the children should be able to discover numerous species of these animals. Observe what the animal is doing, noting whether it is inactive or if it appears to be eating the plant parts. Look for pupal stages, marked by cocoons; larvae, which generally do the greatest damage to plants because of their voracious appetites; and masses of eggs. (Hand lenses will be useful in finding the eggs.) Note how many different kinds or stages of animals are living on the same plant.

The children may choose a plant, clip off the parts containing animals, and drop the entire specimen in a preserving jar containing 70% ethyl alcohol. On the jar, put the name of the plant on which the animals were found. If the name is not known, identify the type as grass, bush, etc.

A few children may use nets to sweep through vegetation that has not been disturbed by other investigations and catch flying insects. With each step, the children should make a slow, even pass through the tops of the vegetation. The motion should somewhat resemble sweeping a floor in slow motion. After about twenty passes, each student should twist his net closed so that the specimens will not escape.

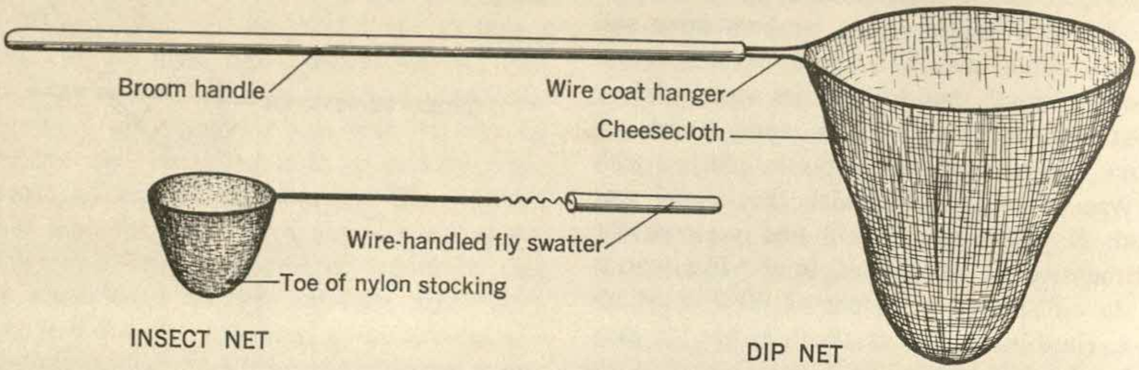
MAKING AN INSECT KILLING JAR



If the children do not wish to kill the specimens, have each sweeper bring his net to an old sheet spread out on the ground. Shake the contents of the net onto the sheet. Many interesting insects will go scurrying, hopping, and flying across the sheet, and the contrast between sheet and insect will make viewing easier. If children wish to preserve the specimens, have them shake the contents of the net into killing jars. After several minutes, transfer the dead insects to cigar boxes.

The students may also want to catch butterflies and moths. Since these insects struggle when caught and may injure their fragile wings, an adult may sprinkle a few drops of chloroform on the net before the hunt. (*Caution: Chloroform is poisonous and explosive! It should always*

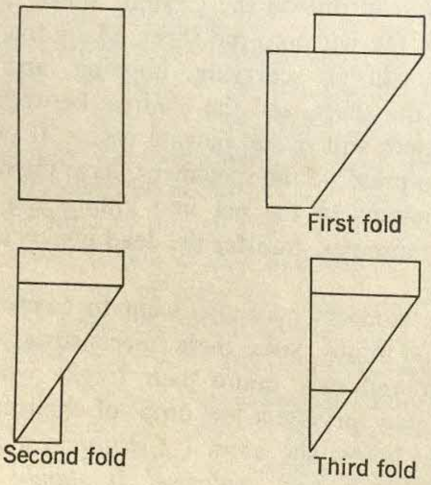
MAKING A NET



be handled by an adult.) The drugged insects may be shaken into the killing jar when caught. When dead, pick them out by grasping the bodies (not the wings!) with tweezers, and fold them in sheets of paper to prevent damage to the wings.

One or two boys, with the help of an adult if necessary, should slowly roll over a decaying log or a large stone. The other children should be ready to observe what goes scurrying away or burrows deeper when the log or stone is lifted. A few students should be ready with forceps or tin cans and spoons to capture slugs, centipedes, and millipedes. These may be put in jars containing some of the medium in which they were discovered, or preserved in 70% alcohol. Reptiles and amphibians may also be under the log or rock. These may be caught with kitchen strainers or nets and transferred to large jars. When the students have finished their observations, they should return the log or stone to its original position so that the habitat will not be destroyed for those animals remaining in it.

MAKING AN INSECT COLLECTING ENVELOPE



During the trip, children may have found gophers, salamanders, turtles, garter snakes, and other animals that may be carried back to school for further observation. Be sure you have prepared temporary homes, such as boxes and gallon jars with holes punched in the lids.

Follow Up

Preserved animals may be prepared for display. Soft-bodied specimens should remain in a preservative, like alcohol. Hard-bodied insects may be relaxed by leaving them several days on a damp sponge. They then may be arranged on pins. Live animals should be made as comfortable as possible in artificial habitats. Many of these animals cannot be kept successfully in captivity. Many of them eat only other living animals, such as earthworms and mealworms. If adequate food and living conditions cannot be provided for the captives, they should be released in the area where they were found. All specimens should be correctly labeled. A good reference book or field guide should be used for label information.

All groups should prepare a summary of observations and correlate their learnings around the theme "Living Things Depend Upon Each Other and Their Environment." They could prepare a mural for the classroom or hall and display photographs and specimens from their trip.

Guide Sheet
VISITING A POND

Materials needed:

Rubber boots or sneakers for wading
Notebooks for recording observations
Strong string (about 20 feet long) and heavy fisherman's sinker for sounding
Yardstick for measuring depth of water
Thermometers mounted on wood or metal
Clear plastic bags
Light rope or nylon lines and large hooks for dredging
Enamel tray for laying out specimens
Scissors for cutting plants
1-gallon jars for temporary homes
Small jars, dip nets, and kitchen strainers (large) for catching specimens
Rowboat

Environmental factors
How does climate affect the pond?
What is the water cycle?
What is the relationship of the water cycle to the drying out of a pond?
How deep is the pond?
What effect does the depth of water have on a pond's inhabitants?
Which part of the pond is coldest?
Which part of the pond is warmest?
How do you account for the difference of temperature of the water?
How are light and temperature related?
How does the kind of environment affect the life in it?

Plant life
How does the depth of the water affect plant life?
What do green plants need to make food?
How do plants that are submerged compare with those that live in shallow water?
How do plants that are submerged compare with those that live on dry land?
What happens to a water plant when it is taken out of water?
How do you explain the effect that removal from water has on a water plant?
How does the arrangement of leaves help a plant?
What is plant succession?
What do you think the plant will look like several years from now? Why?

Animal life
Where in the area are animals found?
Which animals live in the water?
Which animals live on the water?
Which animals live both in and on the water?
How do you account for the animals that may live both in and on the water?
Are all the animals that live in a pond of the same or similar species?
Where do animals find shelter in a pond?
Where do animals find shelter along the shore?
What do the animals eat?
What makes up a typical food chain in a pond?
What makes up a typical food chain on the shore?
How do these examples demonstrate that plants and animals are interdependent?

VISITING A POND

A pond is an ideal place to investigate one of the major characteristics of most biomes—continual change.

A pond is in the act of disappearing. Even a deep, freshly dug, man-made pond is in the first stages of extinction. As the microscopic plants and animals that are its first inhabitants die, they settle to the bottom. Larger aquatic plants take root in water shallow enough to permit the passage of light, and their debris begins to collect on the bottom, making the pond even shallower. Then larger, seed-bearing land plants that can grow with their roots in water invade these shallow areas and contribute to soil accumulation. Eventually the depositing of debris produces a bog, which may drain and form dry land. Thus a pond becomes dry, first along the banks, then progressing toward the center. As the pond goes through its various stages of extinction—from deep water, to shallow water, to bog, to dry land—it changes as an environment. Consequently, the populations in it change too.

By comparing the inhabitants of the deep water, shallow water, banks, and bordering lands, the students will become more aware of how living things affect their environments and how changes of environment affect living things.

If possible, try to visit an old pond, one that has existed for at least ten years. Older ponds usually have a wider range of ecological succession than do newer ponds; that is, there is greater contrast between their plant and animal populations.

Advance Preparation

The same kinds of considerations apply to visiting a pond that apply to visiting a field. The students may conduct this field trip as a climax to studies in class or as an introduction to principles of ecology to be explored.

Students should try to answer the questions suggested in the guide sheet. They may do their investigations in sequence or simultaneously.

Environmental Factors

One of the major considerations in how long it takes a pond to disappear is climate, for in addition to extinction brought about through the deposit of organic matter, water is also evaporated from it into the atmosphere.

The students may discuss the local climate and its effects on the amount of water in the pond and its probable effects on the length of time it may take for the pond to disappear. If the students have not explored the water cycle, now may be a good time to introduce it. Have a student dip his hand into the pond and make a wet handprint on a rock. Why does the handprint disappear? The children should relate the evaporation of the handprint with the evaporation of water from the pond, and discuss how the condensation of water vapor returns water to the pond as rain. In terms of the water cycle, in what type of climate might a pond exist longer?

The students should estimate the depth of the pond in various places. If you have a boat, an adult and one or two children, wearing life preservers *(no matter how much they claim they swim well!)*, should row to the center of the pond and sound its depth. They can do this very easily by tying a heavy string to a large fisherman's sinker and slowly lowering it until it strikes the bottom. Then, grasping the string at the water line, they may haul it back into the boat and measure with a ruler the amount of string between the sinker and the point they are holding. Record the depth, in feet, in a notebook. The students should make several other soundings in the same manner and record their results. Children on the shore may make measurements with yardsticks.

At the same time that the depth is being measured, temperatures at the various depths may also be measured. A thermometer, preferably one mounted on a wood or metal scale, which will protect it against breakage, should be tied to the sounding string, about 1 foot above the sinker. Let the apparatus remain submerged about 3 minutes, then pull it up and read and record both temperature and depth. The students on shore may make temperature readings in shallow water, in marshy ground, on the bank, on large rocks, and further inland. When comparing their readings, the students should note that the more light, the higher the temperature. They should discuss why deep water is not only dark, but cold, and relate the differences in light and temperature to the kinds of plants and animals present in each region of the water and on land.

Plant Life

The depth of the water helps determine what kinds of plants grow in it. Some plants require little light and grow deeply submerged. Others require varying amounts of light and are found at levels where they get the amount adequate for their needs. These plants are specialized to grow at specific depths. When the depth changes, they can no longer grow, and they die.

Submerged plants can be dredged up for examination with weighted lines bearing large hooks. If a boat is available, row out to a fairly deep part, drop the line to the bottom, and row a few strokes toward shore, dragging the line behind. If no boat is available, a careful student or an adult may cast the line from the bank and pull it back in. (*Caution:* When dropping or casting the line, be very careful not to snag anyone with the hooks.)

Several plants, with such animals as snails and crustaceans attached, will probably be caught on the hooks. Ashore, spread the plants out on a rock or, for better viewing, on an enamel tray. The entire class should examine the catch. Note what kinds of stems and leaves the plants have and compare them with those of plants growing along the shore. The parts of the plants bearing animals may be clipped off and placed in a gallon jar of pond water for further study at school. Do not dispose of the rest of the plants immediately. Instead cut a land plant and place it beside a water plant. At various intervals check the states of both plants. In hot sun, the water plant should become dry and brittle in about an hour, depending upon the humidity of the air. The land plant, on the other hand, may have wilted only a little. Students who have had some work in botany will realize that land plants are protected against the drying effects of evaporation by a waxy layer of cutin on their surfaces. This layer greatly inhibits evaporation. Water plants, which are not normally exposed to such large amounts of air, do not have this adaptation.

Look for plants like water parsnip, which grows half in and half out of the water. Note the differences between those leaves that are submerged and those that are aerial. Put a plant of this type on a rock, and notice which leaves dry out first.

Students may wade into knee-deep water for first-hand observations of water lilies, duckweed, spatterdock, and similar plants. They may scoop up some of the free-floating duckweeds and put them in pond water for transportation back to the class for an aquarium. Have the students contrast the way in which the leaves of the water lily are arranged with the way in which the leaves of land plants are arranged. The water lily's pattern, called a mosaic, permits more light to strike the plant.

Near the shore, with their "feet" in water, may be cattails and rushes. Beyond these plants are the swamp grasses, which form a narrow ring of vegetation around the pond. Sometimes, if the area is not well drained, swamp grasses extend rather far inland. If this is the case, the students may estimate the former size and shape of the pond. Students should be careful in walking through swamp grass. Although the area may appear to be solid ground, they may sink into muddy debris.

Beyond the boggy ground there is solid ground. The forms of vegetation on solid ground vary too, as discussed in the previous section, "Visiting a Field."

The students should briefly summarize what they have observed about plant succession, and try to predict what will happen to the pond.

Animal Life

Many forms of animal life are present in and around ponds. Fish, insects, crustaceans, snails, and flatworms may be found in the water. Water striders, water boatmen, and back striders—insects with long legs—may be seen scurrying rapidly across the water. Amphibians, such as frogs and salamanders, live both in and near the water, and certain insects, such as the dragonfly and mosquito, spend part of their life cycles in the water. Aquatic birds, such as ducks, may be observed along the shores and among the grasses.

Before the students wade into the water to make observations, they should squat on the shore beside shallow water and look into it. On the surface may be frog and fish eggs (in the early spring) and mosquito larvae. These may be collected with small jars. If the students have difficulty in spotting these forms, they should look on the bottom for shadows cast by the eggs and larvae and then locate them by the position of their shadows. Also look on the bottom for crustaceans, like crawfish, which may burrow into the mud if you frighten them. Rocks on the bottom will be covered with simple green plants, called algae, and perhaps snails. Collect a jar of pond water and examine a drop under a microscope when you return to the classroom. One or two rocks, complete with inhabitants, may be picked up and put in a gallon jar containing pond water. Another rock may be put on land to observe what happens to the algae and snails.

The students may then wade knee-deep into water to find out what kinds of animals live on plants in the water. When the students turn over the leaves of water lilies, they will probably find snails and the eggs of water insects. By wading out and picking up the leaves, they will probably have disturbed some of the small insects and crustaceans that live among the stems of floating plants. These may be caught with dip nets and transferred to temporary homes in jars. The soil at this level is very soft and easily stirred up. Using sticks, the students can poke around the mud and, using kitchen strainers, try to catch any animals they stir up.

The students will find that the submerged stems of cattails and rushes are covered with algae. These plants provide food for the tiny crustaceans, plant-eating worms, and small water beetles that inhabit the area. On sticks and stems protruding from the water, they may also find dragonfly and damsel fly pupae. The entire stick may be collected, placed in a jar, and taken back to the class for an aquarium.

Along the border of the pond dwell aquatic birds and numerous amphibians, like grass frogs. The frogs may be caught by hand, a rather exciting means of capturing specimens, or with a net. The students may also find a bird's nest with eggs. Do not disturb the nest or handle the eggs.

When the animal forms present in the area have been surveyed, the students should discuss how they are dependent upon the area for food and shelter. A simple food chain could be summarized, starting perhaps with the algae and the small crustaceans, snails, and insects that feed on them.

Follow Up

Back in class the students may arrange their specimens in aquariums and bog terrariums. They should make the artificial environments resemble, as closely as possible, the natural environments of their specimens. This will provide good discussion material for review of the factors that make up an environment and how these factors determine the kinds of living things found in the environment.

VISITING OTHER BIOMES

Almost any region has numerous areas where children may study plants and animals and their natural environments. The sites presented in this book were chosen because they, or minor variations of them, may be found in most parts of the United States. Some schools, however, are located in areas where more unusual sites are available. Children living in a desert region have an excellent opportunity to observe and study many unique plant and animal adaptations and may enjoy the sudden, quick burst of beauty and the flurry of activity when the desert is in bloom. Tidal pools and rocky seacoasts in small areas present whole lessons in ecology and ecological succession. In a mountainous area, the variations between northern and southern slopes provide contrasting biomes in which the influences of temperature, moisture, and amount of light sharply differ. Near large cities, the biomes of fresh water ponds and rivers may be compared with those of water polluted by industrial and home wastes.

No matter where you live, there is an exciting biome awaiting exploration.

VISITING THE ZOO

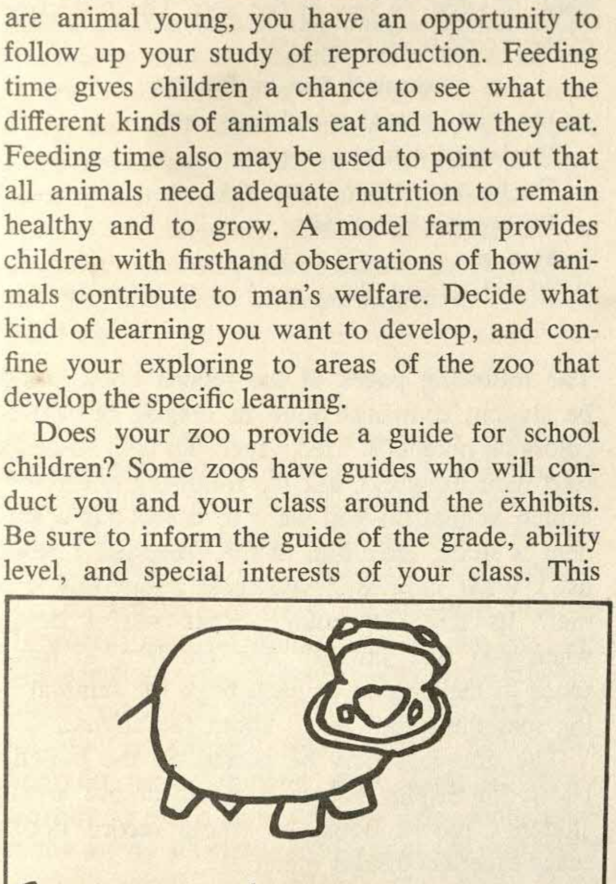
Zoos are maintained for the study and preservation of numerous animal species. Lions, tigers, kangaroos, penguins, and other animals are imported to this country so that we may become familiar with the wide variety and diversity that exists within the animal kingdom. Wild animals native to the United States, such as beavers, prairie dogs, and bears, are also kept in zoos for this reason. Many children—particularly those who live in cities—are not aware of the wide range of wild animals that live not far from them. Raccoons, snakes, and deer are found near cities in many parts of the United States, but most people do not see them except in zoos. In addition, many species would be extinct except for the efforts of zoologists and other interested people, including you and your students.

Most zoos are *not* good places to study ecology, the interdependence of living things. Keepers feed the animals their meat or plant foods, and veterinarians keep them healthy with modern medicine and methods of sanitation. Some zoos, however, have good habitat groups, or areas in which the geographical features of an area and the animals and plants within it are cultivated. There is a definite movement in zoos and museums to build habitat groups resembling, as closely as possible, natural environments. If your zoo maintains such habitat groups, some features of ecology can be studied. Carefully point out how man maintains the balance between living things and where the balance is self-maintaining.

Advance Preparation for the Teacher

Find out what your zoo or local animal farm has to offer. The zoo may publish brochures on the history of the zoo, its more interesting special features, maps, guidebooks, and guide sheets designed especially for teachers and their classes. When is the best time of year to visit? Is it spring-time when there are newborn animals? Is it early summer when most of the animals are outdoors? Is it fall when the coats and colors of some animals are changing to adapt to winter weather? When is feeding time? Does your zoo have special features for children, such as a model farm where the children can see cows milked and sheep shorn? Is there a children's zoo where the children can play with rabbits, goats, geese, guinea pigs, and other animals? The answers to these questions may suggest projects you can develop in class before visiting the zoo. If there are animal young, you have an opportunity to follow up your study of reproduction. Feeding time gives children a chance to see what the different kinds of animals eat and how they eat. Feeding time also may be used to point out that all animals need adequate nutrition to remain healthy and to grow. A model farm provides children with firsthand observations of how animals contribute to man's welfare. Decide what kind of learning you want to develop, and confine your exploring to areas of the zoo that develop the specific learning.

Does your zoo provide a guide for school children? Some zoos have guides who will conduct you and your class around the exhibits. Be sure to inform the guide of the grade, ability level, and special interests of your class. This will help him plan the kind of tour most appropriate to your teaching purposes.


I saw a hippopotamus
open his mouth for a
peanut, he has a big
mouth.
Claudia

Find out whether the zoo or animal farm has special features that will require that the children spend money. Several zoos sell animal food for a nickel or dime per packet. This kind of spending may serve a valuable purpose. Having an elephant sniff and feel a child's hand for a peanut or pellets and watching him transfer the food to his mouth is a thrilling experience for the child. It is also a valuable lesson on how the elephant eats. Watching the hippopotamus stretch his enormous jaws to catch peanuts and pellets can lead to a study of comparative anatomy.

If you are not familiar with the zoo, you should visit it alone before taking the class. Although the distance between the reptile house and the lion house may appear on the map to be a short walk, you may find that it is time-consuming and tiring. Also, where will you eat? Is there a place to picnic, and should children bring their own lunches, or is there a facility where they can buy cheap lunches?

Whatever you decide, plan ahead. You'll get better results.

Advance Preparation for Students

Why are we going to visit the zoo? The children should have firmly in mind the kinds of things they can expect to see in a zoo. A general discussion of why there are zoos is a good opener. If you have decided to stress a particular learning, like nutrition or reproduction, your classroom activities may be directed toward visiting the zoo as a climax of the learning.

If your zoo has habitat groups, you can discuss with your children what habitat groups are and why they are set up. The children will probably raise questions that you cannot answer. Keep a list of these questions, and when you visit the sites, bring them up again. The answers may be obvious to the children as they view the sites, or you may have to rely on an authority at the zoo.

Several teachers have found the following method a good motivational tool and an excellent means of reviewing what the children learned through visiting a zoo.

Obtain in advance a list of the animals you can expect to see in your local zoo. The list may range from specific animals, such as the aardvark, to general kinds of animals, such as snakes. The children may collect photographs of these animals from magazines, such as *Natural History, Life, National Geographic,* and other sources. Mount these on large construction paper, leaving enough room at the bottom for a class-dictated general description. Then individual children or groups of children can research some facts about the animals in junior encyclopedias and other references and report their findings to the class, using the photographs to enrich their reports. The reports should include the name of the animal, its general appearance, where it is found, what it eats, how it obtains what it eats, and some unusual characteristics about it.

When each report is finished, ask the class to summarize and relate the facts to what they know about adaptation and ecology. For example, "The zebra has sturdy legs and hoofs and can run fast to escape its predators, the lion and jackal." Post the summarized facts under the animal's picture.

At the Zoo

Emphasize the original purpose of your visit to the zoo. If you are visiting habitat groups, raise the questions asked in class. Children might ask the guide or curator how biologists study the natural homes of the animals within the groups and then duplicate these features in the zoo. What materials do they use? How do they control the temperature and moisture conditions for various animals? Where do they obtain the trees and other kinds of vegetation found in these habitat groups? What research must scientists do before preparing an artificial habitat? How do foods given in captivity compare to foods eaten by animals in their natural environments? Through this kind of questioning, the students can determine to what extent the plants and animals are dependent upon each other in this artificial environment.

When you visit the animals the students have discussed and posted for display, ask questions based on the discussions. By looking at the tiger, what do you think he eats? Why do you think so? How does he catch his food? ("Tigers have sharp teeth and claws, which they use to catch the animals they eat" is much more significant when the children see the tiger yawn and stretch his claws.)

Follow Up

When you return to the classroom, using reviews, investigations, or demonstrations, reinforce what the children learned. For example, the habitat group experience might be drawn upon by children for setting up their own terrariums. The discussion at the zoo should have made the children aware that certain species thrive in certain environments, while others do not. Utilize these learnings by applying them to the kind of terrarium you can build and maintain in class.

Each child can also make his own record book of what he saw at the zoo. The first page of the record book might be:

Animals I Saw In The Zoo

The most unusual animal I saw was ....
The largest animal I saw was ....
The fiercest animal I saw was ....
My favorite animal was ....
because ....
What I learned about my favorite animal was
....

The following pages of the record book could be student drawings done in crayon or watercolors on notebook-sized paper. To help students start their drawings, ask the following questions: Which animal do you want to draw? (If a student is stuck, refer him to the "Animals I Saw" list.) What impressed you most about this animal? Its size? Its color? What was it doing when you first saw it? Ask children to leave space at the bottom of each page for summarizing something they recall about the animal.

The drawings may be posted on the bulletin board for display before they are bound in the student's record book, or whole record books make excellent display material.

VISITING A BOTANICAL GARDEN

A botanical garden is beautiful; for this reason alone it is worth a trip. However, there are more important reasons for visiting a botanical garden. Students should be fully aware that without plants, there would be no animal life. Since all animals depend directly or indirectly upon green plants for food, the success of various plants in adapting to their environments is vitally important to all life. When a botanical garden is approached as a place to study the ecology and adaptations of plants, the visit becomes an interesting, firsthand observation of how the wide range of plant life obtains nourishment, grows, and reproduces—the basic activities essential to all forms of life.

Advance Preparation

How you plan the kind of visit to a botanical garden depends upon the amount of work your students have had in botany. For beginning students, that is, those who have had little or no work in the subject, it would be best to stick to a general tour.

Investigating the following basic concept should provide beginning students with hours of pleasurable and worthwhile observation in the garden: *In order to grow, a plant needs the proper amount of moisture, temperature, and light. These environmental factors are needed in varying amounts by different kinds of plants.*

With this statement in mind and notebooks in hand for recording observations and questions that may arise, the students are ready for their field trip.

At the Garden

You may begin asking questions based on the concept above: Which plants grow in the shade? Which grow in full sunlight? How many shade plants do you see in full sunlight (and vice versa)? What do you conclude? Which plants are growing on rocks? Do you see them growing elsewhere? How do you account for the fact that trees aren't growing on rocks? Why aren't grasses? Which plants are growing in water? What do you note about their leaves, stems, and roots? How do these compare with those of plants growing in soil? How do you think water gets to the leaves of plants growing in the soil? Are all plants green? What do you notice about those that are not? Is it possible that some of these plants could live on other planets? Are some of these plants being grown under conditions similar to those in a spacecraft?

As students answer these questions, others will arise. Some may be answered on the spot, but most may be reserved for class discussion and investigation. In many cases, you will find the Activities in Chapter 1 of this book helpful in investigating and demonstrating some of the ideas that will arise during your visit to the botanical garden.

VISITING AN AQUARIUM

An aquarium contains a wide variety of animal and plant species adapted to life in the water. Since about 70 per cent of the earth's surface is covered with water, the importance of water as an environment and the importance of adaptations to this environment cannot be overemphasized.

Advance Preparation

Animals that live in water include fish, mammals, and a wide variety of lower animals, from complex invertebrates to one-celled protozoans. Most aquariums display numerous kinds of fish, from under 1 inch to over 10 feet long; a few mammals, like the seal; and several invertebrates, including squid, crabs, anemones, jellyfish, and starfish. Frequently the plants required by some of these animals for food and camouflage are placed in the tanks with the animals that require them. In these cases, you have a good opportunity to study the interdependence of living things. In most tanks, however, the ecological approach is difficult to maintain. If a rare, hard to find species of fish is imported at great expense, it would be folly to place its natural predators in the same tank.

At the Aquarium

An aquarium, is an excellent place to study the adaptations of different species to life in the water. How do the various animals obtain the oxygen they need to breathe when in the water? How do they move about in search of food? How do they find the food they seek? Can fish smell? With what sense organs do they smell? How do they reproduce? Do fish sleep?

If you are studying classification, an aquarium offers many opportunities. Family and species names are given together with common names, and usually a few pertinent facts about members of each family are listed. Students can learn to pick out some of the external features that distinguish particular families. For example, the seahorse and the pipefish, a long straight-bodied fish, are classified in the same family. They don't appear alike at first glance, but a look at their mouths and the egg-incubating sac on the males will reveal similar characteristics. Through studying fish, students will rapidly learn to disregard obvious similarities like color and size and learn to observe more subtle characteristics.

Students should have certain basic ideas in mind in order to distinguish the various animals they may see at an aquarium. Short oral reports on vertebrates (tuna, sharks, and other fish); invertebrates (squid, crabs, crayfish, coral, clams, anemones, jellyfish, and starfish); and water-living mammals (walruses, seals, whales, and porpoises) will help students distinguish these groups. In discussing these last two groups, you also have an opportunity to stress that scientific names are preferable to common names, which are often misleading. Jellyfish and starfish are not fish; dolphin is a name commonly applied to both a fish and a mammal more properly known as a porpoise.

Student's research projects should help them find out how each group obtains nourishment, grows, and reproduces. How is each adapted to its watery environment? How do these groups compare with one another in performing their life functions?

With a little advance preparation, students will get more out of their visit to the aquarium.

BIBLIOGRAPHY

Biological Sciences Curriculum Study. *High School Biology*. Green version. Chicago: Rand McNally and Company, 1963. An excellent, well-illustrated textbook for secondary school biology students. Combines the wisdom of earlier scholars with the advances of modern instructional methods and materials. Emphasizes the understanding of ideas through investigation and inquiry rather than the memorization of facts.

Biological Sciences Curriculum Study. *Pamphlet Series*. Boston: D. C. Heath and Company, 1963.

Morholt, Evelyn, Brandwein, Paul F., and Joseph, Alexander. *A Sourcebook for the Biological Sciences*. New York: Harcourt, Brace and Company, 1958. High school teachers will find this sourcebook filled with valuable facts and suggestions to aid them in stimulating their students' interest. Reference tables, diagrams, bibliographies, and projects with instructions for performing them are some of its features.

Petrides, George A. *A Field Guide to the Trees and Shrubs*. Boston: Houghton Mifflin Company, 1958. A guide to the field marks of all the trees, shrubs, and woody vines that grow wild in the U.S. and Canada. Includes information on growth habits, environment, and uses by men and animals.

Viorst, Judith. *Projects: Space*. New York: Washington Square Press, Inc., 1962. This book will appeal to the student interested in reading about, and experimenting in, space research experiences.

Zim, Herbert, Burnett, Will, and Fisher, Harvey. *Zoology: An Introduction to the Animal Kingdom*. New York: Golden Press, Inc., 1962. An excellent survey of the animal kingdom with 450 colorful drawings. All major phyla are discussed, as well as evolution, embryology, genetics, and ecology.

PETERSON NATURE FIELD BOOKS

A well-indexed and illustrated guide series made popular by its simplified identification of species. Patterns, impressions, and distinctive marks, rather than anatomical differences and measurements, are used as the basis of identification of species.

Peterson, Roger Tory. *A Field Guide to the Birds*. Boston: Houghton Mifflin Company, 1947. A guide to the outdoor identification of birds found east of the Rockies, emphasizing the distinguishing characteristics of birds when seen at a distance, including information on habits, sounds, nests, and ranges.

Peterson, Roger Tory. *How to Know the Birds*. Boston: Houghton Mifflin Company, 1962. This revised and enlarged edition describes the 54 chief bird families, tells where to find them, and how to recognize them by their flight, silhouette, etc.

PUTNAM'S NATURE FIELD BOOKS

An illustrated pocket-size handbook series, with accurate and authoritative descriptions, handy for field trips and usable for science students of all ages.

Anthony, Harold Elmer. *Field Book of North American Mammals*. New York: G. P. Putnam's Sons, 1928. A popular guide for identifying mammals known north of the Rio Grande with information on the animal's habits, appearance, range, and life.

Durand, Herbert. *Field Book of Common Ferns*. New York: G. P. Putnam's Sons, 1949. A useful guide to ferns, with accurate descriptions for identifying 50 species of eastern America and directions for their culture.

BIBLIOGRAPHY

Hillcourt, William. *Field Book of Nature Activities and Conservation.* New York: G. P. Putnam's Sons, 1961. Absorbing and instructive projects pertaining to birds, mammals, reptiles, fish, insects, wild flowers, and trees are clearly described for nature lovers.

Lutz, Frank Eugene. *Field Book of Insects.* New York: G. P. Putnam's Sons, 1935. The purpose of this book is to answer common questions about some 1,400 commonly observed species of insects of the northeastern United States. Contains indexes arranged by habitat, plant, and entomology.

Mathews, F. Schuyler. *Field Book of American Trees and Shrubs.* New York: G. P. Putnam's Sons, 1915. A handy guide to American trees arranged by family, with color illustrations and concise descriptions of the character and color of species common throughout the United States. Contains an index and keys for identification by leaves and by bark.

Morgan, Ann Haven. *Field Book of Animals in Winter.* New York: G. P. Putnam's Sons, 1939. The winter activities of various animals from sponge to mammals are presented in this book. Interesting discussions on hibernation and seasonal migrations are included.

Morgan, Ann Haven. *Field Book of Ponds and Streams.* New York: G. P. Putnam's Sons, 1930. A well-illustrated manual that describes the common forms of plant and animal life found in fresh water. Includes information on water plants, insects, fish, and amphibians.

Rickett, Harold William. *The New Field Book of American Wild Flowers.* New York: G. P. Putnam's Sons, 1963. Fully describes over 1000 species as to time of bloom, habitat. Lists and indexes the common and scientific name for each species.

Schrenkeisen, R. *Field Book of Fresh Water Fishes of North America.* New York: G. P. Putnam's Sons, 1963. Identifies and classifies fresh water fishes of North America including information on nomenclature, range, size, characteristics, and habits.

Thomas, William S. *Field Book of Common Mushrooms.* New York: G. P. Putnam's Sons, 1948. A practical and authoritative guide to the identification of mushrooms, with directions for cooking those that are edible.

PICTURE CREDITS

Page 30: John Gerard
Page 33: Robert C. Hermes
Pages 34 and 35: Orville Andrews
Page 37: J. C. Allen and Son
Page 45: Allen D. Cruickshank
Page 47: J. Wexler
Page 48 Top: Mitchell Campbell
Page 48: Karl H. Maslowski
Page 49: Chas. J. Ott
Page 51: Lorus and Margery Milne
Page 69: Walter Dawn